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The Science Demonstration in the Junior-Senior High School

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John Burroughs School, St. Louis, Mo.

Part I.

This paper is the result of numerous inquiries, both verbal and written, for material on the organization and presentation of a science demonstration. The general absence of papers on the subject in no way suggests the absence of demonstrations, and the writer is aware that several very excellent demonstrations have become yearly events in a number of schools in various parts of the country.

It is the object of this paper merely to set down one experience with the demonstration. I trust that it may serve as a guide or a stimulus to some teacher in the field of science.

When the word "demonstration" is suggested, one usually associates it with the extraordinary or the bizarre, and truly enough it may be; and yet another view is perfectly possible, that is, to associate it with the commonplace, everyday activities of home, pleasure or business. It is in this sense that we wish to use the word in the development of this article. A science demonstration of the everyday activities of boys and girls in the classroom.

There are numerous educative values which one might justly claim for a public demonstration of this type, among which might be mentioned both social and individual outcomes; one might also claim the development of certain specific abilities, such as leadership, organization, and others; one might claim the development of character traits, such as self-confidence, etc.

It is not, however, our purpose to discuss these more intangible outcomes but to confine ourselves to a more specific point, the motivation of science instruction through the medium of the demonstration.

The first problem faced in getting the demonstration under way is selling the idea to the children. One might anticipate, as we did, some difficulty on this point; but, to the surprise of everyone, they took to it most enthusiastically. More experience has taught that it is a sort of child instinct to want to show or tell someone else of his achievement. This is undoubtedly one of the reasons that children's demonstrations, whatever their nature, are usually successful. The child accepts them as whole-hearted activities and the inevitable outcome is success. This point is borne out by the fact that since the inception of the science demonstration as an annual part of the school program at John Burroughs, other departments have taken up the idea and have met with equal success.

Fig. 1. Science room in which this demonstration was housed.

In the following pages several points relating to the science demonstration will be discussed. These are:

1. Growth of the Science Demonstration.
2. The Organization and Presentation of the Science Demonstration.

PART I.

THE GROWTH OF THE SCIENCE DEMONSTRATION.

The first science demonstration at John Burroughs School was given in April, 1924. Children from the seventh, eighth and ninth years of General Science participated, as did also pupils from a tenth year Biology class. Figure 1 shows a cut of the General Science room in which this demonstration was housed.

Because of the limited floor space, only a very small part of each science group could actually participate in giving the

demonstration. Everyone, however, had a part in its preparation. Not only were the demonstrators greatly crowded, but the visitors experienced considerable discomfort and great difficulty in seeing some of the more popular demonstrations.

The plan during this first exhibit was to have the visitors move along in front of the demonstrators in single file, starting at the first and following through to the last demonstration. This proved very unsuccessful, as the aisles soon became crowded. The visitors wanted to take some time at each demonstration, and the result was congestion and almost total disruption of the plan. However, the exhibit as a whole proved most successful, especially as an educational activity.

A list of the topics used for demonstration at the first exhibit are given below:

7th Year General Science.

A *DEMONSTRATIONS.*

1. A simple telephone system.
2. A simple wireless sending and receiving set.
3. An electrical wiring plan.
4. How the electric flatiron works.
5. A hot-water heating system.
6. A steam heating system.
7. A simple power plant.
8. Making soap. (A small cake of soap was presented to each visitor.)
9. Making ink.
10. A simple storage battery.
11. The removal of spots and stains.

B. *EXHIBITS* (Placed on a side table).

1. The cigar-box telegraph.
2. An electric horn.
3. Various kinds of inks.
4. Electric buzzers.
5. Wiring plan for the school bell system. (The boys who made the plan board also wired the temporary bell system for the school.)
6. A home-made aneroid barometer.
7. Air thermometers.
8. Water thermometers.
9. Bird houses.
10. Nesting materials box.
11. Bird feeding stations.

8th Year General Science.

GENERAL TOPIC—AIR.

A. *DEMONSTRATIONS.*

1. How air exerts pressure.
2. Measuring air pressure.
3. The effects of heat on air.

4. Moisture in the air.
5. Weather maps.
6. Weather forecasting.

B. *EXHIBITS.*

1. Various types of barometers.
2. Note books.
3. Weather vanes.
4. Sling psychrometers.
5. Charts on the subject of fire.
6. Charts on various cloud forms.
7. Radio sets.
8. Home-made telegraph sets.

9th Year General Science.

GENERAL TOPIC—FIRE.

A. *DEMONSTRATIONS.*

1. Why illuminating gas is dangerous.
2. Why gasoline is dangerous.
3. How dust explodes.
4. How to put out fires.

B. *EXHIBITS.*

1. Charts on proper and improper methods of furnace regulation.
2. Chart on how coal burns.
3. Various types of chemical fire extinguishers.
4. Various types of fuels.
5. An automatic sprinkler system.
6. Note books.

10th Year Biology.

A. *DEMONSTRATIONS.*

1. Remedies containing acetanilid.
2. A home-made blood-pressure apparatus.
3. Testing foods.
4. The balanced aquarium.
5. The study of yeast.
6. Bacteria and their work.
7. The study of osmosis.
8. The study of photosynthesis.
9. Forest conservation.

B. *EXHIBITS.*

1. Carbon dioxide cycle chart.
2. Insect nets, stretching boards, cyanide bottles, etc.
3. Life-history of the malarial mosquito.
4. Life-history of the house-fly.
5. Civic-biological agencies at work in St. Louis.
6. Various methods of grafting.
7. Apparatus to show how our lungs work.
8. Bird exhibit:
   (a) Charts.
   (b) Nest collections.
   (c) Houses, feeding stations, etc.

Profiting by the experiences of the first year, the second science demonstration was planned and given in February, 1925. The floor space was increased from the 1100 square feet used the first year to more than 2500 square feet. The number of pupils participating was increased from 26 to 56, and the method of handling the visitors was changed to a plan which allowed them to go about to any demonstration at will. They were urged however to see the demonstrations in sequence as suggested by the numbering of the demonstrations. Several new types of activity were added and from every point of view it was vastly more successful than the first exhibit.

Figure 2 shows a cut of part of the floor space added in the second demonstration, and Figure 3 gives the floor plan and general layout.

Fig. 2. The floor space added in the second demonstration.

Below are listed the topics used by the various classes for demonstration in the second exhibit:

7th Year General Science.

A. *DEMONSTRATIONS.*

1. Simple experiments with the phonograph.
2. Fireproofing wood and cloth.
3. Making carbon dioxide.
4. The simple storage battery.
5. Making flasks from electric light bulbs.
6. The difference between inhaled and exhaled air.
7. Making paint.
8. How a Bunsen burner works.
9. Working with glass tubing.
10. Making oxygen.

B. *EXHIBITS* (Placed on a side table and on the wall).

I. CHARTS:

1. The life of Galileo.
2. The life of Lavoisier.
3. The life of Priestley.
4. The life of Robert Boyle.
5. The story of the Alchemists.
6. The life of Faraday.
7. The life of Davy.
8. The story of glue.
9. The story of glass.
10. The story of iron.
11. The story of leather.
12. The story of sugar.
13. Chart of a Bunsen burner.
14. Fahrenheit and Centigrade thermometers.
15. Chart of a balanced aquarium.
16. The life of Bunsen.
17. The story of salt.

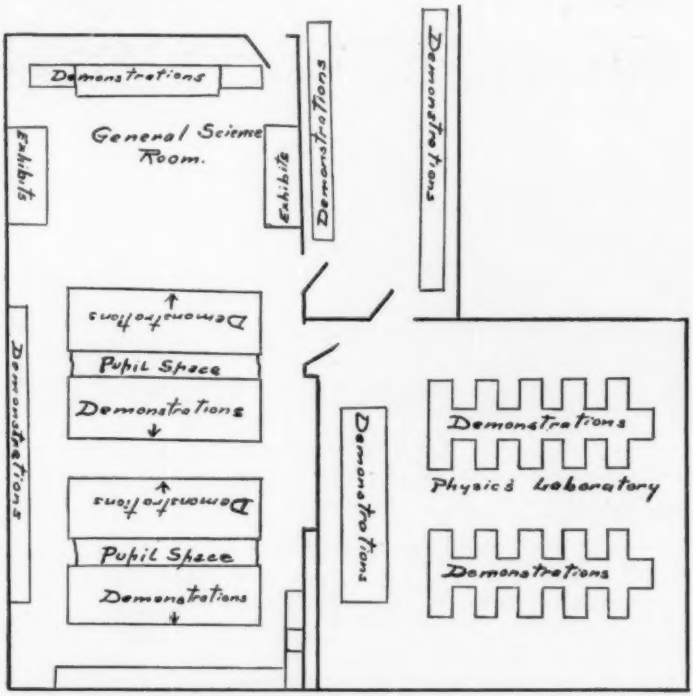


Fig. 3. General floor plan of the second demonstration (1925).

II. EXHIBITS:

1. Glass tubing exhibits mounted on cardboard.
2. Science scrap-books.

3. A home-made microscope.
4. Leaf prints.
5. Patent medicine clippings.
6. Home-made flasks.
7. Home-made Bunsen burners.
8. Air thermometers.

Fig. 4. The demonstration in the General Science Room—1926.

8th Year General Science.

GENERAL TOPIC—AIR AND WEATHER.

A. *DEMONSTRATIONS.*

1. Air occupies space.
2. Air has weight and exerts pressure.
3. How to test the air capacity of the lungs.
4. A study of ventilation.
5. Warm air is lighter than cold air.
6. Why winds blow.
7. Weather observations.
8. The preparation and chemical properties of oxygen.

B. *EXHIBITS.*

1. Air thermometers.
2. Electric light bulb weather forecasters.
3. A wet weather forecaster.
4. Wind vanes.
5. Home-made aneroid barometers.
6. Sling psychrometers.
7. Chart on the Centigrade and Fahrenheit temperature scales.
8. Biography chart on the life of Galileo.
9. Biography chart on the life of Torricelli.
10. Biography chart on the life of Pascal.
11. Rain gauges.
12. Chart on the history of the barometer.
13. Science scrap-book.
14. Charts of tuberculosis statistics in St. Louis.
15. Chart-graphs of a month's temperature records.
16. Chart-graphs of barometric readings over a three-week period
17. A thermograph.

9th Year General Science.

GENERAL TOPIC—THE ST. LOUIS WATER SUPPLY SYSTEM.

A. *DEMONSTRATIONS.*

1. What water is composed of.
2. Freezing and melting.
3. Does water always boil at the same temperature?
4. Pumps and how they work.
5. Siphons and how they work.
6. How water is distributed.
7. Water purification by filtration.
8. Water purification by distillation.
9. Water purification by coagulation.

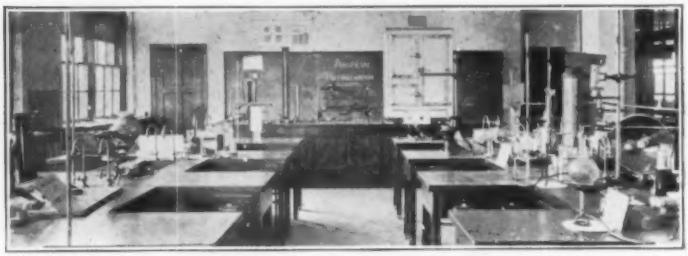


Fig. 5. The demonstration in the Physics Room—1926.

B. *EXHIBITS.*

1. Science scrap-book.
2. Map of the present St. Louis water supply system.
3. Enlarged detailed drawing of the purification plant.
4. Collection of pictures showing the various parts of the present system.
5. Pictures of centrifugal pumps.
6. Graphs showing pumping capacity.
7. Graphs showing present rate of consumption.
8. Graph showing water consumption in other large cities.
9. Graph showing rate of increase of population in St. Louis.
10. Enlarged map showing the proposed Missouri River plant.
11. Story chart on the history of the St. Louis water supply system.
12. Graph showing the decrease in death rate from all causes since 1867, with water supply legend written in.
13. Chart showing the chemical composition of river water.
14. Chart showing the number of bacteria at various points in the purification process.
15. Chart showing types of purification.
16. Chart showing rainfall in St. Louis.
17. Chart showing a rapid sand filter in cross-section.

10th Year Biology.

GENERAL TOPIC—THE WORLD FOOD SUPPLY.

A. *DEMONSTRATIONS.*

1. Sources of the world food supply.
2. Roots and their relation to the world food supply.
3. Stems and their relation to the world food supply.

4. Leaves and their relation to the world food supply.
5. The uses of foods in our body.
6. The types of foods.
7. The amount and type of food we need.
8. The effect of narcotics, beverages and stimulants on the body.

Each of the above topics had charts and demonstrations to properly amplify them.

At the conclusion of the second science demonstration it had unquestionably become an annual affair at John Burroughs. The children displayed great eagerness prior to it, and everyone felt that the outcome was of such a nature as to really contribute developmental opportunities which were not offered in the regular classroom work.

Fig. 6. The demonstration in the hallway—1926.

At this point in the development of the science demonstration idea it was very evident that if it was to be used as an educative device, opportunity must be provided for the activity of every student. It was also evident that these activities should be of such a nature as to provide each individual with that type of activity which would serve best in his development. It thus became a matter of individualized activity.

Upon this basis the third science demonstration was planned and given in April, 1926. The exhibit was of such a nature as to provide activity for every child taking science and also to provide a type of activity in the case of each child which, to a certain degree, was commensurate with his abilities and with his needs. Such a program needs the greatest care, both in its planning and execution. These points will be discussed in detail in later portions of the paper.

In the third science demonstration the floor space was increased to 4000 square feet, and the entire science enrollment of 120 pupils participated. Figures 4, 5 and 6 are photographs of the exhibits.

The topics demonstrated in the third exhibit may be obtained from the sample program given in a later part of the paper.

[Part II, The Organization and Presentation of the Science Demonstration, will be published in the next issue.]

A Study of the Offerings of General Science Texts

W. J. KLOPP,

Supervisor of Science Teaching, School of Education,
University of Southern California, Los Angeles.

A careful analysis of the contents of nine general science textbooks reveals some interesting facts concerning what is actually offered to ninth grade pupils in our junior and senior high schools. In the light of the generally accepted objectives for general science and the many studies made attempting to show their realization, the writer became interested in this study to see whether the authors of texts gave evidence, consciously, of the contribution their products are to make to pupils of the ninth grade.

Nine texts were carefully selected as listed in Table I; every page was evaluated on the basis of number of lines devoted to science content; every map, illustration, table, etc., was also evaluated on this linear basis, so as to establish a total linear space content factor for each text. Eight major sciences were considered as follows: Physics, Chemistry, Biology, Agriculture, Physical Geography, Home Economics, Physiology, and Astronomy. All space devoted to each major science was noted and reduced to per cent of total space of science content. Comparisons were then recorded in per cents by tables, to show variability of each one of the major sciences in the nine texts and to show the variability of the offerings of each text to all the major sciences.

Table II reveals some interesting facts relative to what the authors of General Science text books think should constitute the offering for eighth and ninth grade pupils. For example,

TABLE I.

General Science Texts Reviewed.

1. Rowell, Introduction to General Science.
2. Caldwell and Eikenberry, General Science.
3. Hunter and Whitman, Civic Science in Home and Community.
4. Hessler, Junior Science.
5. Nichols, Science for Boys and Girls.
6. Trafton, Science of Home and Community.
7. Van Buskirk & Smith, Science of Everyday Life.
8. Webb and Didcoct, Early Steps in Science.
9. Snyder, General Science.

TABLE II.

The Per Cent of Space Devoted to Each of the Eight Specific Sciences by Each Author.

Authors	A	B	C	D	E	F	G	H	I
Physics	29.	12.6	21.1	34.8	49.1	32.	30.5	34.5	51.0
Chemistry	10.9	4.1	3.8	9.2	6.3	17.	19.8	4.8	3.7
Biology	14.55	21.9	24.	20.0	19.0	20.4	49.0	32.2	10.3
Agriculture	10.6	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0
Physical Geog.	14.8	55.14	7.2	17.3	9.6	5.5	0.1	8.1	8.4
Home Economics	9.3	0.0	7.8	0.0	1.9	5.0	0.0	7.7	8.1
Physiology	5.6	0.0	20.44	7.4	10.0	16.0	0.0	7.7	15.0
Astronomy	5.0	6.16	7.3	11.2	3.5	4.0	0.0	5.0	3.4

TABLE III.

The Average Specific Science Offering by All Authors.

Physics 32.7	Physical Geography 14.00
Chemistry 8.9	Home Economics 4.4
Biology 24.5	Physiology 9.1
Agriculture 2.04	Astronomy 5.06

TABLE IV.

The Range of Specific Science Offerings by All Authors.

1. Physics ..... 12.6% to 51.0%	5. Physical Geog.. .1% to 55.14%
2. Chemistry ..... 3.7% to 19.8%	6. Home Econ..... .0% to 9.3%
3. Biology ..... 10.3% to 49.0%	7. Physiology .... .0% to 20.44%
4. Agriculture...Only 2 out of 9 made specific contribution	8. Astronomy .... .0% to 11.2%

the author of textbook A offers 29 per cent of physics and 15 per cent of biology, and author I offers 51 per cent of physics and 10 per cent of biology. I, offers over four times as much physics as B, and only half as much biology; while B offers seven times as much physical geography as I. Chemistry and physics vary from half as much of the former to a seventeenth as much. Biology seems to hold its own in all the texts, which would lead us to believe that the authors have come to some common agreement as to the contribution biology makes to the objectives.

Table III gives the average specific science offering for all

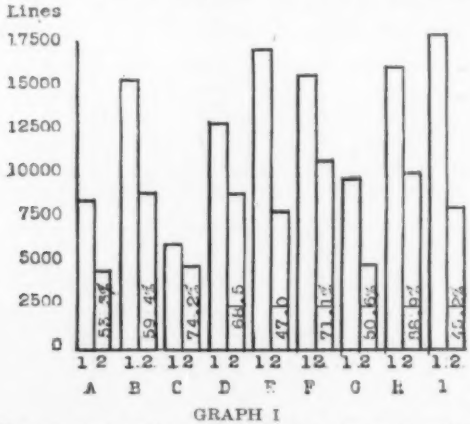
authors. Author B appears to fall far below the average of six out of the eight sciences, being a trifle above in Astronomy and entirely out of proportion in physical geography. Author G offers content in but three sciences: physics, chemistry and biology, giving exactly half to biology. If the averages in Table III represent an equitable distribution of science content for a course in General Science, it is very apparent that few texts in Table II will meet the needs of the course, and especially would this be true of the offerings of authors B, G and I, one-third of the texts considered, and partially true of all but two of the group. The fact remains that such offerings must needs be enriched by carefully selected supplementary material by way of outside reading and more extensive lecture-table demonstrations.

The findings of the value derived from extensive reading of General Science by Dr. Curtis[1] from a questionary received from one hundred five selected high schools, revealed the fact that about 70 per cent of the schools reporting used one text; that about 50 per cent assigned outside readings; that in 82 per cent of the schools replying extra readings were suggested but not required; 85 per cent of the teachers testified that "outside reading functioned noticeably." Yet they also agreed that from 5 to 100 per cent of the pupils do this reading in whole or in part. This still leaves us with the query: What per cent of the pupils using books with lean content derive this extra text reading benefit as compared with those using the richer offering? Not attempting to under-rate the value of the scientific content offered by the better American newspaper, is it not a fact that the relationship between the richness of content offering to the value of type content selected for actual reading by the pupil is about as wide as that between the number of pupils reading much material and that number reading five per cent of the assignment? This then would lead us to the conviction that if General Science objectives are to be realized through enriched content, either certain text offerings must be richly supplemented or entirely eliminated, and if the teacher works out a plan to supplement the text, he must needs take stock of the variable likes of his group.

---

1 Curtis, Francis D. "Some Values Derived from Extensive Reading of General Science," Teachers College Series, Columbia, 1924.

Graph I is a picture of comparison of nine texts, comparing total content with total science content offered. The margin of difference being utilized by introduction, index, appendix, score cards, summaries, questions, etc. As for instance, Author D devoted 12 per cent of his space to pictures, 8 per cent to miscellaneous material, etc. Author B devoted 25 per cent to pictures, 9 per cent to experiments, 2 per cent to questions.



GRAPH I

The per cent of linear space devoted by each author to general content of General Science material as compared with the per cent of space devoted by each author to the following eight specific sciences: Physics, Chemistry, Biology, Agriculture, Physical Geography, Home Economics, Physiology, and Astronomy. The graph shows also the difference in amount of space devoted to general content by nine authors.

No. 1 represents the total content expressed in linear space.

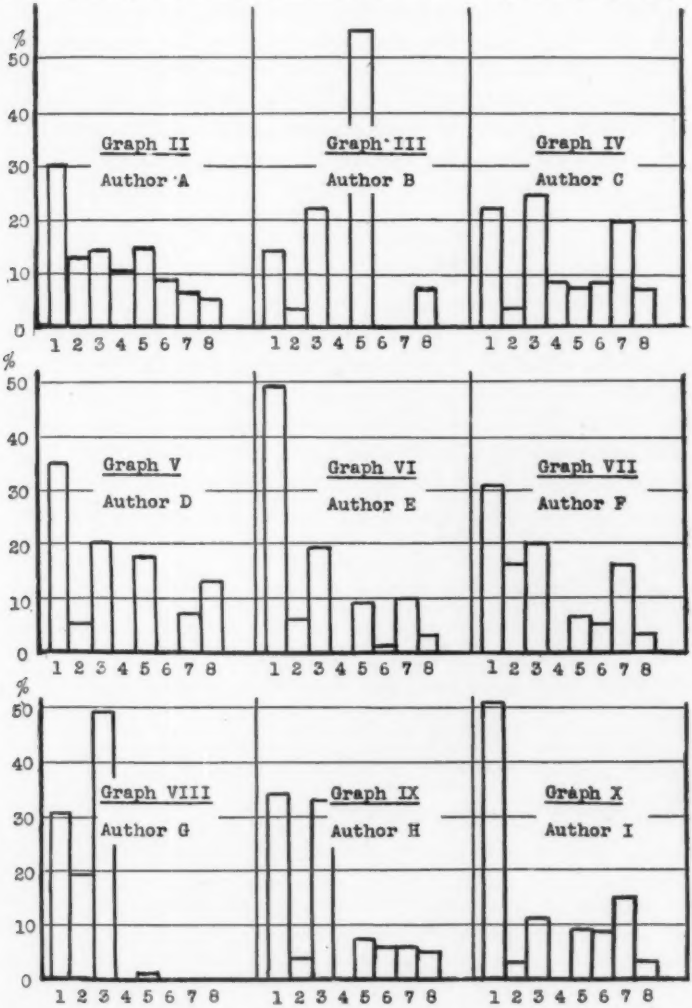
No. 2 represents the per cent of the total space devoted to the eight specific sciences.

Graph I should be read: Textbook A devotes 53% of its contents to the eight sciences, while F devotes — 71% to them, etc.

Graphs II to X, inclusive, give us a picture of the amount of space each author devotes to each of the eight specific sciences, and incidentally a profile of his concept as to the prescribed scientific content necessary for the realization of their objectives.

Graphs XI to XIII, inclusive, show a major science comparison of all authors, by giving a picture of the variable amounts of physics and chemistry and biology, etc., offered by

each author. As, for instance, agriculture, as such, appeared in two texts, and home economics in five. Physical geography

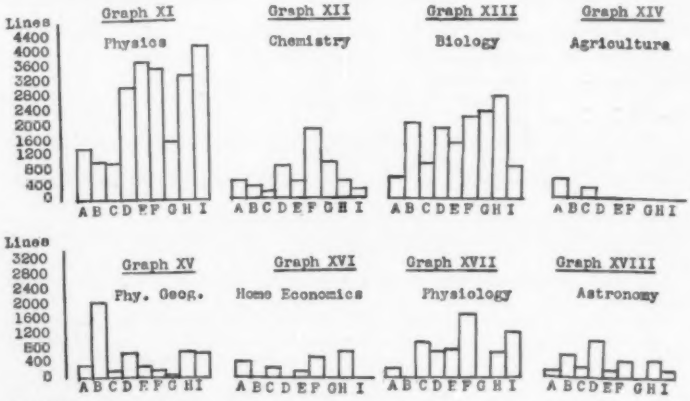


GRAPHS II to X show the per cent of linear space devoted to special scientific content by the different authors.

1 Physics
2 Chemistry
3 Biology
4 Agriculture
5 Physical Geography
6 Home Economics
7 Physiology
8 Astronomy

appeared in every text, but text B contained as much as the other eight together.

Table V appears after the graphs, primarily because it is my purpose to present a general picture of the offerings of authors and then show the findings of a survey of texts, magazine articles and other source materials for aims and objectives of General Science.



GRAPHS XI to XVIII show the per cent of linear space devoted to each one of the major sciences by all the authors.

TABLE V.

Aims and Objectives of General Science.

The following list is taken from a carefully selected list of references, and is arranged in order of frequency of appearance. (The number in parenthesis represents the frequency.)

1. (25) To understand and utilize the familiar facts of daily experience and environment.

2. (14) To become acquainted with and make habitual the scientific method and thought.

3. (13) To give an introduction or entrance to the various specialized fields of science.

4. (12) To train in the defining of problems which arise and in solving them scientifically.

5. (12) To develop in the student proper ideals, habits, tastes, attitudes, appreciations, and bring out the moral values involved.

6. (11) To have some understanding and appreciation of the various phenomena of nature.

7. (9) To understand, appreciate, and to some extent inculcate in their own lives the true scientific spirit.

8. (9) To base the study of science upon psychological divisions, which are in turn based upon the needs and interests of the pupils.

9. (7) To serve as an introduction to the whole field of science as a whole or unity.

10. (7) To develop the vocational and utilitarian values of the various activities of science.
11. (6) To arouse interest in science in the pupil from the standpoint of the amateur or consumer.
12. (6) To develop the social and civic values of science.
13. (4) To give sufficient insight into science to act as an educational and vocational guide for the pupil.
14. (4) To develop faith in the worth of the problems attacked and in the possibility of solution of them.
15. (4) To develop the desire to learn about things scientific.
16. (4) To give intellectual training in grasping the abstract or theoretical.
17. (4) To cultivate the powers of observation of the pupil.
18. (3) To impart certain useful scientific knowledge for those not going on with further science work in school.
19. (2) To give training in the formulation of recreative interests in the pupils.
20. (2) To develop the pupil's sense of responsibility and power of carrying things through by himself.
21. (1) To train the pupils to utilize their capabilities and abilities to the fullest extent.
22. (1) To educate the child for the present life.
23. (1) To educate the child for his own and his community's health.
24. (1) To educate the child for intelligent citizenship and proper solution of civic problems that he will meet.
25. (1) To develop the aesthetic values of science in the student.
26. (1) To free the pupil from superstitions, undue fears, tangents, extremes, and so forth, by a basis of usable facts.

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School Science and Math., February, 1926, pp. 121-6 (by Caldwell).
A Report on the Objectives of General Science Teaching. Crecelius, Philipine Sch. Sci. and Math., 23:313-320, 1923.
Vitalizing the Problem of Good Citizenship by Means of the General Science Course. Bowden, G. A., Sch. Sci. and Math., 24:394-401. 1924.
Organization of General Science in the Seventh and Eighth Grades of Junior High School and Ninth Grade of Senior High School. Davis, Ira C. General Science Quarterly, 8:564-572. Sch. Sci. and Math., 24:487-494. 1924.

The fifty or more books and articles read gave the results as indicated in this table, the number in parenthesis representing the frequency of appearance of the stated aim or objective.

In order to strengthen my position on the necessity of selecting supplementary material on the basis of child needs and interests, I am presenting a study made by Mr. McIntyre, principal of the John Adams Junior High School of Santa Monica, California, in which he makes a survey of the student attitudes toward General Science.

His study gives the reaction of the 8A group of 189 boys and 103 girls. Just why 79 per cent of both boys and girls are interested in Earthquakes and Volcanoes as compared with 46 per cent in Structure and Care of the Body is difficult to explain, yet, if you follow the girls' group you can readily determine major and minor interests. (Table IX.)

Tables VII and IX give the results of the reactions of the ninth grade to two specific questions: (1) I did not like General Science because ——; (2) I liked General Science because I was interested in ——.

There were 126 boys and 122 girls who responded. Here we have a definite attitude relative to home work which represented extensive reading assignments. There were 52 boys and 10 girls who objected to the course on the basis of too much home work, and 66 objected to the course because of not enough experiments. A definite interest in astronomy was declared by 124 boys and girls, and out of nine texts reviewed I found 11 per cent to be the highest relative offering in this field. Here then is still further evidence of specific interests in scientific content which some texts do not provide and others too sparingly.

Tables VIII and IX give the responses from the Juniors and Seniors to the more significant questions based upon the influence of a course in General Science upon the advanced courses in science, such as physics, chemistry and biology. The majority of boys and girls evidently did not regret having taken the course and also indicate a strong attitude toward the course as a supplement to advanced courses in science. The results show a definite interest in astronomy even after having had General Science.

The Senior group was smaller than the other groups consid-

ered, yet it gave evidence of sustained attitudes in favor of General Science as a contributing factor to the mastery of the advanced sciences.

TABLE VI.

Election of General Science.

	Grade 8-A	
	Girls	*Boys*
I do expect to elect General Science as a 9th Grade subject	53	156
I do *not* expect to elect General Science as a 9th Grade subject	48	33

TABLE VII.

Why General Science is Disliked by Some.

	Grade 9	
I did not like General Science because:	*Girls*	*Boys*
1. It was not interesting	34	22
2. It had too much homework	52	10
3. It was too hard	40	5
4. There were not enough experiments I could work for myself	26	40
5. There is nothing in General Science I can use in daily life	16	6
6. I was not interested in any of the 15 topics listed (Table IX)	1	4

TABLE VIII.

Looking Back on the General Science Course.

If I could again become a 9th Grade student and General Science were an elective—	*Juniors*		*Seniors*	
	Girls	*Boys*	*Girls*	*Boys*
I would elect General Science	53	43	68	74
I would *not* elect General Science	27	13	38	16
I would rather have a course in General Science—				
Before I took biology, physics and chemistry	70	48	83	76
After I took biology, physics and chemistry	4	0	4	3

GENERAL CONCLUSIONS.

In the light of the facts presented, it appears that:

(1) The authors of General Science text books fail to agree upon both type and amount of content offering for the realization of the objectives of General Science.

(2) That they do agree upon the major objectives to be realized.

(3) That the larger majority of teachers use but one text.

(4) That, though 80 per cent of the teachers subscribe to the effective value of extra reading assignments, they are uncertain as to the amount of reading that is actually done:

(a) by the inferior groups;

(b) by the average groups;

(c) by the superior groups.

(5) That the selection of extra reading material is not made on the basis of pupil needs and interests.

(6) That too much stress is laid upon the particular material of special interest to the teacher.

(7) That unless the teacher is well prepared in the field of science the supplementary work will be poorly selected, demonstrations rarely given, and field trips not attempted.

TABLE IX.

Subject Matter and Interest.

	I expect to elect General Science in the 9th Grade because I am interested in:		I liked General Science because I was interested in:		I liked best the chapter in General Science dealing with:		I liked best the chapters in General Science dealing with:	
	Grade 8-A		Grade 9		Juniors		Seniors	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
1. Storms	44	10	46	44	21	20	30	26
2. Foreign countries and their customs	49	16	28	45	24	18	35	24
3. Stars and planets	56	8	64	60	39	22	54	34
4. Earthquakes and volcanoes	68	11	56	50	27	21	38	28
5. Wild animals	57	14	38	51	18	20	12	25
6. Domestic animals and pets	44	11	20	38	13	14	14	15
7. Wild flowers and trees	45	8	23	45	21	12	35	15
8. Garden flowers, trees and plants	33	14	24	45	28	10	30	13
9. Electric power and use	52	11	52	58	14	30	16	50
10. Gasoline power and use	32	7	30	35	7	28	7	39
11. Steam power and use	39	6	33	37	7	25	8	35
12. Simple machines and how they run	42	12	38	39	3	24	13	33
13. Wireless and radio	52	12	48	50	13	26	13	35
14. Soil, rocks, geysers and natural wonders of the world	52	11	60	59	20	23	47	34
15. Structure and care of body	40	6	38	48	24	14	41	30

(8) That the interests and ardor of many children will be sacrificed because of too limited a course of study offered, as is found in many modern texts.

(9) That children of different schools where different texts are used cannot compete on the same basis because of the variable content to which they were exposed. This would be true especially in situations where a standardized test was given to determine the final grade or for college entrance, as for example, Form A of a certain test containing the following elements: 38 per cent physics, 12 per cent chemistry, 30 per cent biology, and 20 per cent agriculture, astronomy, geology, etc., combined, would produce many casualties in groups exposed to textbooks B, G or I, in Graphs III, VIII and X.

The Present Status of the Controversy Demonstration *versus* Laboratory Method

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The future of Science Teaching and of developing a general scientific attitude rests largely with the effectiveness of our methods of instruction in science.

Much has been said and written as to whether the demonstration or the individual laboratory method is more effective. False impressions are abroad in spite of the care of the research students and some of the reviewers to limit their conclusions by the scope and extent of the original studies.

The material for this article is derived from an unpublished report of the writer made while serving as research assistant with the Lincoln School of Teachers College, Columbia University. It represents an analysis of all the published studies relating to methods of teaching in natural science up to and including the year 1926. Where they were available, the original manuscripts were consulted, otherwise the publications deposited in the several libraries of colleges where such research was conducted, or the reports as furnished to educational journals, were used. The fullest account in any one source is in a book by F. D. Curtis.[1] In the space here allowed is given

1 F. D. Curtis, Investigations in the Teaching of Science, 1926, Blakiston's Sons and Co., Philadelphia.

a brief summary of the present status of the above investigations relevant to the above issue as it concerns the high school. Much of this is given in outline form for the sake of brevity and readability.

Total number of science teaching *investigators* reporting 28
Total number of separate *studies* 34
Number of distinctly different published studies *relevant to the issue as stated* .....8[2]
(This number expresses also the number of investigators who have reported. Only 6 of these concern us in the present account.)
Number of High School Sciences represented: General Science 1, Biology 1, Physics 1, Chemistry 3.
Number of science experiments or "exercises" in the foregoing: General Science 13; Biology, 12 and 24; Physics (heat only), 14; Chemistry, 3, 10; 25 and 10.
Cases in which the number of students used exceeded 20 *per group* (an arbitrary low minimum) 2
Cases in which the author reports or shows the use of objective tests of at least 10 questions each 4
Cases in which the tests were comprehensive and varied so as to have at least the external form of many-sidedness 2
(A related college study not here reported increases this by 1.)
Cases in which the study was repeated presumably using identical contents and methods 3
Cases in which the identical content and method was tested by other teachers or in other schools .....None
Cases in which modern statistical precautions and computations are used to safeguard the validity and reliability of tests and to measure the significance of the observed differences in averages 1
Cases in which the research was published fully enough so that
a. It could be intelligently criticised in all essential points and
b. It could be repeated with a high degree of identity by other persons, for verification or otherwise .....None

The reader's attention is called to the amazing inadequacy of the studies, displayed in the table above, to serve as the basis of important conclusions. It is on these meagre findings that we are asked to believe that the two methods have practically equal value, or that the demonstration method is superior. The first error is in the assumption that there is a standard demonstration or laboratory method. And even if standard, then we would, in fairness to both methods, have to test them under still other methods of organization and presentation. The second error is in leaving the impression that any one science has been adequately represented—a point which will be discussed later. The third error is in neglecting to consider whether all the valuable effects of either method have been measured by the tests given. Another error is in assum-

2 This includes a three page report by T. D. Phillips, 1920. Unfortunately the data are too inadequate to serve our purpose. It is apparently less scientific than the other studies.

ing the reliability of the data obtained with such small populations, with tests of unknown validity and reliability, and with doubtful control of teaching conditions, however sincerely these matters may have been attended to.

An additional error is the naive reliance on data secured on single trials. We are nowhere assured that the so-called repetitions in the few cases where seemingly used, were identical in method or content. In fact, the original documents seem clearly to show otherwise.

The only scientific attitude to take is to consider all the researches so far reported as being mere first attempts to solve the problem; and the findings as only roughly indicative of certain general facts. Briefly stated, the findings, considered as merely tentative, point to the following conclusions:

1. As far as *information* is concerned either method is quite as effective for immediate retention.
2. The laboratory method in practically every instance yields superior results for permanence of retention. The superiority is not large.
3. Some experiments and certain phases of some experiments are learned better by one method and some better by the other method.

   Exactly what specific facts determine this difference has yet to be investigated.
4. Some students learn better by one method and some by the other. Intelligence seems to play an important part,, as noted in the studies by F. G. Anibal[3] and W. D. Carpenter.[4]
5. As far as the findings are limited to the conditions, teacher ability, pupils used, etc., the experiments chosen for these studies yielded somewhat superior results in at least verbal memory by the demonstration method. That is, there were more demonstration experiments yielding higher scores than individual laboratory experiments yielding higher scores.

   This statement is to be judged by all the caution demanded by these considerations: representativeness of

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3. Anibal, Fred G. Unpublished Master's Thesis, U. of Chicago 1922-23.

4 Carpenter, W. D. Ph. D. Dissertation. Teachers College, Columbia University.

experiments; comprehensiveness, reliability and validity of tests; teacher bias; possibility of errors due to chance, etc.

The following data may be gleaned from the published studies: (Note—For the sake of classification a superiority is decided by a minimum difference of 5% in averages of 50% or over)

	What Was Done	What Happened	Explanation	Comb'd Total
I. 5 Exercises having same score by either method	4	4	1	3
Exercises having a higher score by demonstration method ...	6	6	9	9
Exercises having a higher score by laboratory method	2	2	2	0
II. 6 Exercises having the same score by either method	3	1	1	6
Exercises having higher score by demonstration method ...	5	7	6	4
Exercises having a higher score by laboratory method	3	3	4	1

A large advantage in the time used was noted for the first study, but the differences were greatly reduced in the second study. Apparently conditions were different in each study.

In another[7] similar study, using only biology materials, we have the following display. The scoring of the separate parts of the laboratory and demonstration exercises was intended to measure separate abilities.

	Object	Procedure	Results	Conclusions	Comb'd Total
I. Exercises having same score by either method	2	8	3	2	6
Exercises having a higher score by demonstration method ...	6	1	6	3	2
Exercises having a higher score by laboratory method	4	3	3	7	4
II. Exercises having same score by either method	4	8	5	4	5
Exercises having a higher score by demonstration method ...	5	3	5	6	6
Exercises having a higher score by laboratory method	3	1	2	2	1

5 Cunningham, H. A. Master's Thesis, University of Chicago, 1920. First study: Biological and Chemical experiments were done by sophomores in high school.

6 Second study. The laboratory and demonstration exercises were scored on the above three phases of learning, presumbaly to test a variety of abilities.

7 Cooprider, J. L. Master's Thesis, University of Chicago, 1922-23.

Delayed tests for the permanence of retention yielded the following averages:

With oral directions		Per cent later score is of original score	
Demonstration	Laboratory	Demonstration	Laboratory
64.17	*65.16*	*55.82*	50.19
With written directions			
63.55	60.24	52.95	*62.20*

In a study of Physics[8] covering part of the study of heat, we find:

I. Exercises having same score by either method 8
Exercises having higher score by demonstration method 4
Exercises having higher score by laboratory method 2

In this study the authors used much more comprehensive and objective tests: a test of ability to apply to concrete situations was given; the immediate and delayed memory were measured; the effect of writing up exercises was also tested, with apparently significant gains in favor of this operation and a small gain in favor of the laboratory method.

Three studies have been made in the field of chemistry. The first was made in 1918, the last in 1925. The first,[9] because it was made so long ago, with unusually small populations (8 per group), will be referred to only briefly. This student found no marked differences as between the two methods, but noted decided individual differences both for immediate and delayed reproduction. He admits the possibility of unmeasured advantages in one method over the other.

In the second study of this group[10] (chemistry) we find the following:

	Higher Intel. Level	Lower Intel. Level
Similar scores by either method	6	3
Higher scores by laboratory method ...	3	4
Higher scores by demonstration method	5	2

This is the last reported study that seriously attempted any form of diagnosis. It is very likely that the greatest gains for progressive teaching will be made by conducting studies of the types of exercises best taught by a given method under certain physical conditions and with given personal factors.

The above author notes great differences in the time and amount of equipment needed for the two methods. Except in the case of greater permanence of retention under certain con-

8 Kiebler, E. W. and Woody, Clifford, reporting to Jour. Ed. Research, 1923.
9 Wiley, W. H. In Jour. of Ed. Psych. IX. 1918.
10 Anibal, Fred G. Master's Thesis. University of Chicago, 1922-23.

ditions this author showed no marked differences in the scores. Presumably only information was measured. The tests are not shown nor are their contents discussed.

The largest piece of work is that done for a recent doctor's dissertation.[11] In this, over a score of schools were used, roughly representative of the whole country; populations of from 1100 to over 1500 pupils were tested; the tests were validated by teachers of chemistry; the reliability of the tests was computed and found high; the data received modern statistical treatment showing the distribution of scores by each method in terms of scores expressed in sigma values. While this method is not yet commonly understood, it gives a definite scientific basis to score values.[12] However, it can be abused quite as easily as the usual method of percent scores and common averages. In the case in hand, the results show that about as many pupils succeeded by one method as by the other, and there were about as many who succeeded much more by one method as of those who succeeded much more by the other method. This author finds a significant difference between the individual and group-of-2 methods, and between demonstration and group-of-2 methods, both in favor of the latter method. Since he worked with large numbers and applied the method of rotation whereby variables were cancelled out, the writer recommends a further study of his report in the Journal of Chemical Education for July, 1926, and of his monograph available at the Bureau of Publications, Teachers College, New York City. His conclusions are very carefully guarded. However, the present writer takes exception to the findings in so far as the method of averaging swamps all the individual and school differences, which may well be the most significant results of such a study. In this study the tests covered mainly (apparently) verbal memory; the teaching conditions were under no control; each teacher taught in a free and unhampered style as to assignments, degree of identity of content and procedure, apparatus, and length of time. This has certain obvious disadvantages as well as advantages.

11 Carpenter, W. D., referred to on page 248.

12 By this method it is assumed that in large populations the scores are distributed in a normal distribution. The standard average is the score of 0 made by the average pupil: 68.26% of all scores constitute the standard range of scores and is placed as between minus 1 sigma and plus 1 sigma. Highest ranks are shown by plus values, lowest ranks by minus values.

GENERAL CONCLUSIONS AS STATED BY THE AUTHORS OF THE STUDIES.

The following are some of the more outstanding and representative conclusions reached by the workers on these researches:

I. TO THE EFFECT THAT THE TWO METHODS YIELD NEARLY THE SAME RESULTS:

a. "The delayed retention is so little different that one method may be considered as good as the other." Chemistry, Anibal, 1922-23.

b. "In the second study the individual work was slightly superior to the demonstration work, but not sufficient to justify (its use)." Biology, Cooprider, 1922-23.

c. "The results secured through the use of the demonstration method were as good, if not superior, in all three types of tests given for immediate knowledge, for permanent retention and for knowledge of how to apply principles and technique in solving a new problem." Physics. Kiebler and Woody, 1923.

d. "The results of this experiment point to the conclusion that the majority of students in high school laboratory classes taught by the demonstration method succeed as well as when they perform the experiment individually . . . (in terms of gain) in specific information and ability to think in terms of chemistry. . . . The second part of this experiment indicates that on the whole the intelligent students will succeed no matter what method of presentation is used in the laboratory." Chemistry. Carpenter, 1925.

II. TO THE EFFECT THAT THE LABORATORY METHOD IS SUPERIOR OR THAT THE DEMONSTRATION METHOD IS INFERIOR.

e. "In every respect the lecture (demonstration?) method is least effective in imparting knowledge to high school students." Chemistry. Wiley, 1918.

f. "A higher percent. of knowledge is retained by individual (laboratory) method in each study." Biology and General Science. Cunningham, 1920.

g. "Individual work should be given in preference to the demonstration." Biology. Cooprider, 1923.

h. "The individual method tended to be superior in those experiments that are especially difficult to perform or in which great care must be exercised to see the exact procedure." Physics. Kiebler and Woody, 1923.

i. "Students were better able to do satisfactory laboratory work when this was preceded by a (long) interval of demonstration work." Chemistry. Anibal, 1923.

j. "It is hoped that administrators as well as class-room teachers, will realize that while the studies so far have shown the value of the demonstration method of instruction for certain abilities, however, so far as we know now, we must consider the usual laboratory method as one of our most efficient means of instruction." "Probably our laboratories can be made to function more effectively." Chemistry. Carpenter, 1925.

III. TO THE EFFECT THAT THE DEMONSTRATION METHOD IS SUPERIOR OR THE LABORATORY METHOD IS INFERIOR.

k. "From the point of view of economy of time, the laboratory method is the most costly." Chemistry. Wiley, 1918.

l. "From the point of view of economy of time, the results favor the lecture demonstration method." General Science, etc. Cunningham, 1920.

m. "Demonstration work is more efficient than individual work." Biology. Cooprider, 1922.

n. "When the demonstration method gives equal or superior results, it is to be preferred to the individual laboratory method because it saves time . . . (besides) permits the instructor to use the time saved in relating the facts and principles to allied phenomena." Physics. Kiebler and Woody, 1923.

o. "The brighter pupils are likely to profit more by the lecture-demonstration method than are the others.
(The same author calls particular attention to the great saving of time and expense by the demonstration method.)
Chemistry. Anibal, 1922-23.

Stressing the need for a discriminating study of methods.
NOTE: See especially items c, g, h, n, o, p above. Other comments on this important matter follow:

p. "The students of medium and lower intelligence seem to profit on the whole a little more from a good demonstration." Chemistry, Carpenter, 1925.

q. "The different methods show *decided individual differences* both for immediate and delayed reproduction." Chemistry. Wiley, 1918.

r. "It is in the *study of individual cases* that most real values may be obtained from a study of this kind. General Science. Cunningham, 1920.

s. (As a rule there are *too many variations* of *individual cases* which are covered up in the general results.)

s. "On the other hand if we wish our students to retain laboratory work, it appears from this study that demonstration work should be given with *oral instructions* and the individual work with *written instructions*." Biology. Cooprider, 1923.

t. "Such facts suggest that the most effective method *depends upon the nature of the experiments themselves*, and suggests the *need for scientifically classifying them*." Physics. Kiebler and Woody, 1923.

u. "There are probably *other abilities* not measured by these tests or by any other tests yet constructed that will rank the individual method higher than the demonstration method." We have *no adequate test for scientific attitude, appreciation, manipulative skill in handling apparatus* or *scientific method of procedure*." Chemistry. Carpenter, 1925.

The above conclusions of the workers in this research into the comparative effectiveness of the two methods are offered for two reasons: they show the present lack of a basis for deciding as to whether one method as a whole is better than another method as a whole; and, secondly, the need for a widespread general investigation of this matter by science teachers in all the sciences. The investigations need not be so burdened with scientific technique as to be beyond the scope of the classroom teacher. Parallel tests should be made at various times of the year; for various kinds of experiments; with different improved types of organization; the uses of superior motivation, etc. At the same time each teacher should make a thorough scrutiny of the types of difficulties and types of

student reactions in each experiment. A careful record of these observations and of the results of objective tests of wide scope should be kept for use in discussions and published statements dealing with these findings.

The Laboratory Attack in Beginning High School Science

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The modern school world is very much alive to the value of testing the efficiency of its work. The past decade has seen the growth of experimental work to an astonishing degree. At the present time a very large number of secondary school teachers are engaged in pedagogical experiments with pupils and with subject-matter. These investigators have a very real purpose in mind; they are attempting to bring together student and subject-matter in terms of genuine psychological adjustment. To lend proof to this assertion, witness the collection of papers reported upon by Dr. Francis D. Curtis in his new and valuable study entitled *Investigations in the Teaching of Science* (P. Blakiston's Son & Co., 1926). In this book he has collected short summaries of twenty-six experiments investigating the learning phase of science teaching, and forty-four studies dealing with science in relation to the curriculum.

Still more recently Elliot R. Downing has called our attention to one phase of experimentation: namely, a comparison of the lecture-demonstration and laboratory methods of instruction in science. His earlier paper, *A Comparison of the Lecture-Demonstration and the Laboratory Methods of Instruction in Science,* appeared in School Review for November, 1925. In this he discusses the work of seven different investigators, some of them his own students, whose published papers date from April, 1918, to November, 1924. In general he believes that they prove the thesis that "the lecture-demonstration method of instruction yields better results than the laboratory method in imparting essential knowledge and is more economical of time and expense." Dr. Downing's second paper, *Individual Laboratory versus Teacher Demonstration,* appeared in the General Science Quarterly for January, 1927,

and is a general summary of the experiments alluded to in his first paper. He points out the saving in time, equipment and expense in the use of the demonstration method. He also points out that the European secondary schools have long used the demonstration method with the bulk of their students. He shows that since the pupils' initial skills are best obtained by imitation, it is little wonder that the demonstration method serves its end so well.

It is an interesting coincidence that I reached very much the same conclusions in an investigation entitled *An Experiment in the Use of Three Different Methods of Teaching in the Classroom,* published in School Science and Mathematics, December, 1921—January and February, 1922.

If one reads the paper carefully he will see that the so-called "oral method" is in reality a modified demonstration method (vide pp. 29-32, School Science and Mathematics, Jan. 1922). It is true that the individuals in these classes were not tested by the modern intelligence tests. On the other hand, the school records and examinations were used most carefully in the DeWitt Clinton High School as a basis of segregation in classes. When one considers the size of the school, at that time over 6,000 pupils, it would seem that grouping of students with like mental abilities would be really much easier than in a small school. To quote Douglass, page 399, *Modern Methods in High School Teaching* (Houghton-Mifflin & Co., 1926): "If but one type of test is to be used, school achievement tests are better for this purpose than intelligence tests." It was the purpose of the experiment to use classroom conditions and to introduce nothing unusual into the schoolroom routine, in order to see if an educational experiment could actually be performed without the distractions brought about by visitors and student-teachers in the practice experimental school. Our experiments must be performed in a normal environment if they are to stand the gaff of workaday conditions.

These experiments at DeWitt Clinton, since they were conducted under normal classroom conditions brought about practical changes in teaching. Because of the obvious bearing on the conduct of laboratory and classroom procedure, other investigations conducted by the questionary method followed the experimental series. This questionary dealt with the biolog-

ical interests of children of high school age and of their preferences for different methods of doing work. A small part of this material was worked out and published in a paper entitled *The Collecting Instinct,* General Science Quarterly, March, 1919. But the coming of the war and the fact that I was in the camps doing war-work during parts of 1918 and 1919, prevented publishing the major part of this work. Since it has a bearing on the work quoted by Downing in his recent articles, I have decided to publish certain findings in the near future.[1]

But one practical result of the above experiment might be noted at this time. The department of biology of the DeWitt Clinton High School, with its 19 teachers, at once began to change certain methods of teaching. In this school biology—which included a good deal of the subject-matter now taught as general science—came in the ninth year. Originally, like chemistry, it was a six-period subject, on one day a double period was programmed for laboratory work. The double period had to be given up because of the very large number of pupils taking the subject—over 2,000. In place of the old type of laboratory work, with printed directions and "busy work" on the part of the pupil, a modified demonstration laboratory period was worked out.[2] Students worked in small groups on *problems,* or the teacher demonstrated such problems to the class. An introductory period was used in which a round-table discussion resulted in the formulation of the problem. So far as possible, this was the work of the students, the teacher leading the discussion. Then followed a demonstration, either by a group of students or the teacher. Frequently this work was varied by an informal investigation of material in the hands of pupils, but with the teacher leading an oral discussion group. As the demonstration proceeded the group was quizzed by the teacher in order to fix points that were not clear in the minds of the less rapid workers. As a result of this joint demonstration and quiz the experiment was then left with the class, and a brief period—from ten to twenty minutes—was given for a write-up of the actual steps of the experiment, but without stressing the conclusion. Again came

1 See School Science and Mathematics for June, 1927.

2 In this work Dr. Frank M. Wheat, now Head of the Department of Biology of the George Washington High School, New York City, was the most active leader.

a class conference, the tentative conclusion was given by several different pupils, and then another brief period was given for the write-up of the conclusion. Thus the demonstration *might* be recorded within the limit of the period. But if the discussion ran over the allotted period (as it frequently did) students were allowed to take their notes home, write up the conclusion, and use this work as a basis for discussion at the opening of the class period the following day.

It will be noted that this was a distinct breaking away from the old type of *laboratory* work, where it was a heinous crime for the student to take away from the laboratory any of the written work before it was corrected. In this DeWitt Clinton method the emphasis was placed on *oral discussion.* The student might use his notes as a basis for his answer, but he had to be able to know what he was doing in the laboratory, and in particular he had to know what he was *trying* to *prove.* As Downing so well says in his recent article, " 'Teach for keeps' must be the slogan." This was our method of "Teaching for keeps," and we got what we were after, over ten years ago!

Indeed, this method reminds one somewhat in plan of the method of Morrison in his book, *The Practice of Teaching in the Secondary Schools* (H. C. Morrison, University of Chicago Press). The great difference is that in the Morrison attack the steps of the teaching cycle compass a larger unit and of necessity last over a considerable number of class periods. In the DeWitt Clinton type of lesson the "exploratory period" would correspond to that part of the period when the problem was sought. The "presentation period" would correspond to the demonstration; the "assimilation" and "organization periods" were foreshadowed in that part of the period where the pupils were self-active and engaged in informal discussion and write-up. The "recitation period" corresponds to the first part of the following period at DeWitt Clinton, when the students were called upon to give their findings of the preceding day's lesson. All of which illustrates, it seems to me, that in teaching, as well as in the other experiences of life, there is literally nothing new under the sun.

I copy the following from my unpublished thesis, presented in 1918 for degree of Ph.D. in the School of Education of

New York University: "We find that the method of science in the form of pure induction is not so well fitted to beginning students' use as we have hitherto supposed. So, as a practical result of this and other investigations, a modification of the formal experimental method to one in which oral questioning and demonstration work is done, has to a large extent superceded the use of the laboratory manual and the inductive experiment in the ninth grade science work of the DeWitt Clinton High School." This statement was made ten years ago. Doubtless many other teachers made the same discovery and met the situation in the same practical way. It is certainly interesting to have the practical results of the classroom verified by the more exact methods of the university. For we are all working, theorizing, testing, with one end in view,—the real usefulness of those precious young lives entrusted to our keeping at a time when they are most plastic and leadable. May we all do our bit in helping them to attain the goal of the efficient life.

A General Science Laboratory

JAMES R. WILSON, Supervisor General Science Department, Phoenix Union High School, Phoenix, Arizona.

General Science has no laboratory. Why? Perhaps there are several reasons. The chief reason is, doubtless, the fact that General Science is the youngest science, and no one has yet taken time to make a laboratory for it. Since General Science has grown to occupy such a large place in our secondary schools, it is time that we give it recognition commensurate with this development.

The writer had planned an inexpensive desk arrangement, which had been used for three years in the Phoenix Union High School, Phoenix, Arizona, and which has been found generally satisfactory. The plan combines three features, namely, a study hall, teacher demonstration work, and a student laboratory, in one room. This means considerable saving of space and, hence, taxpayers' money.

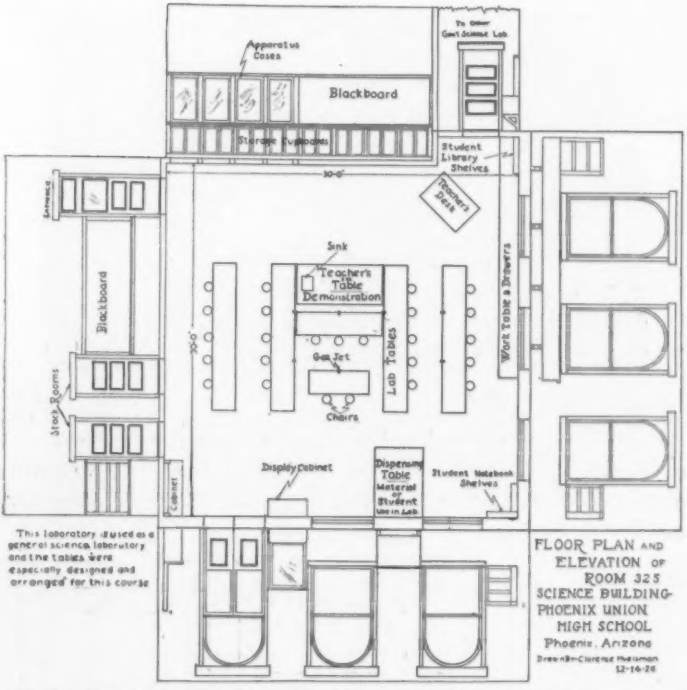

Fig. 1. Sketch showing floor plan of a General Science Laboratory, with walls extended, Phoenix Union High School, Phoenix Arizona.*

Figure 1 shows the general plan of the room, floor plan in the center, with the four walls extended as laid outward flat. The room is about thirty feet square and was formerly a chemistry laboratory. The demonstration table is high enough for every student to see the apparatus and large enough for good demonstrations.

Figure 2 shows the seating arrangement and how all students face the demonstration desk with clear vision. For a demonstration at any time during the period, either by instructor or student, assuming that the apparatus has been previously set up, it is necessary only to ask for the attention of the class and then to proceed at once. The students merely have to "raise their eyes" to give attention, and "lower them" to re-

* Sketches in this article are the courtesy of R. Izer Turner, Head of the Industrial Arts Department.

Fig. 2. Photograph of laboratory shown in Fig. 1. Note the clear vision of the students. Nine of the twenty-five students are within six feet of the apparatus. The farthest student is but fifteen feet distant.

sume their work after the demonstration. This arrangement saves considerable time and thus gives the taxpayer more for his investment.

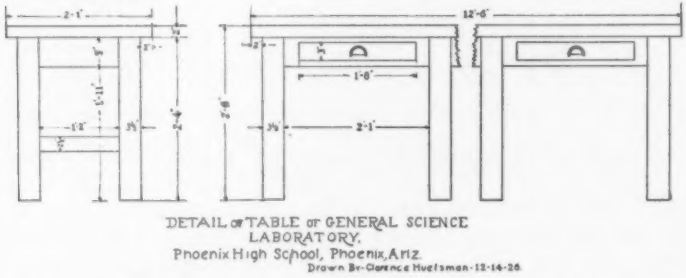

Fig. 3. This sketch gives details of the tables used in the above laboratory as student desks. End and side views are shown.

Figure 3 gives detailed measurements of the tables, end and side views. The demonstration desk is of the same general construction, but is eight inches higher than the student tables. Its top measures 37½″ x 7′ 7″. In our Phoenix laboratory we used soft pine for the frame and maple, with a varnish and wax finish, for the top. By exercising care, very little damage has been done to these tops. The students clean and polish them occasionally. If acids were used to any extent by the students, an acid-proof dressing might be applied. The tables can be made to order by the local planing mill or con-

tractor (keep the money at home). A strong, comfortable chair should be used, with metal buttons on the bottoms of the legs. We use a well-wired oak chair (called the Western Union chair), best shown in Figure 4, which is a photograph of the room sketched in Figure 1.

Fig. 4. Same laboratory as shown in Fig. 2. Table and chair arrangement and demonstration desk shown to better advantage here.

The capacity of the laboratory is twenty-five as arranged, but could easily be enlarged, if desired, and still maintain the same plan. In this plan, nine of the twenty-five students are an average distance of six feet from the demonstration apparatus, and the farthest student is but fifteen feet distant. Compare this situation with the average laboratory of your acquaintance, and the advantage of this seating arrangement will be quite apparent.

The one thing lacking in this laboratory is a large sink with several faucets, in which students can clean apparatus they have used. It can be placed in a corner or on the side of the room. The wall between the two General Science laboratories here is three feet thick, formerly used as hoods in chemistry work, so that apparatus cases for the other laboratory are back of the blackboard in this room (Figure 4), and a blackboard in the other laboratory is back of the apparatus cases in this one, thus making good use of this wall space. Figure 5 shows the "other" laboratory.

No student lockers are used, but materials, such as pens, ruler, ink, dust-cloth, and blotter, are kept in the one drawer in the student table (one drawer for each student in any class),

Fig. 5. View of the "other" laboratory for General Science (see Fig. 1 for its location). These laboratories accommodate twelve General Science classes in our system.

and these materials are used by all of the General Science classes during the day. Each student is charged twenty-five cents for the use of the materials in the drawer throughout the year. This plan is much cheaper for the student than to buy his own material, and it does away with the necessity of locker keys (the bane of a science teacher's life). There is often a surplus left from the fund supplied by this fee, if there are several classes in General Science, and this surplus is usually voted by the students here to purchase wall pictures for our General Science Department.

We have stated some of the advantages of this plan of laboratory arrangement, but for the schools that can afford it and for those that want it, there should be designed a *special* laboratory desk for a *special* General Science laboratory, with all of the drawers, lockers, keys, etc., that can be considered essential to the formal type of desk.

Spring Meeting of Home Economics

The American Home Economics Association will hold its twentieth annual meeting at Asheville, North Carolina, June 21 to 24, 1927, with the Battery Park Hotel as headquarters. An unusual feature of the program will be the opening "annual progress meeting," at which representatives of the various sections of the association (such as food and nutrition, textiles and clothing, and homemaking) will give brief, vivid summaries of the year's scientific progress in their respective subjects.

The Science of Common Things

JOSEPH R. LUNT,
Boston Teachers College.

V. "Ye Old Tinder Box" The History of Fire*

The following articles, as announced at the last lesson, should be ready on your table:

1. A hard stone, the size of your fist, from the beach, roadside, or stone wall. Get granite or quartz if you can.
2. A large knife—a jackknife, carving or bread knife.
3. A sheet of newspaper.
4. Two old cotton handkerchiefs.
5. Two tin plates—such as pie-plates.
6. A box of safety matches.
7. A few "strike-anywhere" matches.

During the past week I have worked overtime reading stacks of letters and papers you sent me. Thank you, boys and girls, for your nice letters. I want all of you to join my class and do the experiments with me. All you children from 1 to 100. As Mr. Packard says—all are invited—the age limits are 1 to 100. More science teachers are giving these talks to their classes each week as part of the regular work. Fine! The Cambridge High and Latin School sent me a wonderful set of papers on my last talk, and the Phillips Brooks School of Dorchester was a close second. Has your science teacher joined our class? Will you invite her to take advantage of these talks? I received two nice experiments this past week, one from Raymond McMaster of Chelmsford, the other from Stephen White of Newton Centre. Thank you, boys.

And now get your pencil and paper ready. I want to give directions for our next science lesson—Monday, December 27. Remember now, I want you all to try the experiment—and it is a good one——"How to Make Water Boil on Ice!" Sounds interesting, doesn't it? Yes, sir! I am going to show you how to make water boil on ice. Have the following articles ready! Write them down.

1. A piece of cardboard, 4 inches square.
2. A candle—get a good one.
3. A few matches.
4. A bowl of snow or cracked ice.
5. An old towel.
6. A hairpin or piece of wire about six inches long.

* Radio Science Lesson given at the Big Brother Club hour of WEEI, Boston, December 13, 1926. Four Radio Science Lessons were printed in the General Science Quarterly for March.

7. Two medicine vials with tight-fitting stoppers. Get the vials from any drug-store. You know what a vial is—it is a small bottle, with straight sides. Get one about 2 inches long and half-inch in diameter. And be sure the cork stoppers are good ones and fit tightly.

All ready, Science Class? Let's start! The subject of our lesson, "Ye Old Tinder Box: The History of Fire."

"The art of producing fire is as old as the world. But who discovered it? Did the first wanderer find it where the Parsee worships in flaming fumes of naphtha? Did the savage see it in the chafing boughs of trees in the wind, or in the lightning's flash, in the ray focusing heat through transparent rock, or in the fiery outburst of the volcano? Yet, as sure as we are here, there was a time, when man, ignorant of the art of fire, first discovered it; when jealous nature holding fast her secret in tightening grasp, at last yielded to the force of human will, and the half-naked savage became master of cold and darkness." He stopped eating his food raw. He warmed his cave in winter. He frightened away wild animals at night with a flaming torch. With fire he learned how to extract metals from rocks. Metal implements replaced the pointed stick and stone hatchet. With these, men began to till the soil and build more comfortable homes. As his knowledge of fire increased he learned how to change iron into steel. This discovery has made possible the remarkable progress of modern times. For with steel man builds giant locomotives and steamships, mighty turbines and generators, comfortable-riding automobiles, and towering sky-scrapers of big cities. And pause—just for a moment think what you and I owe to fire—to that marvelous transformation of energy, heat, light, power, the magic energy released from prehistoric storehouses of crude petroleum or black lumps of coal—*by fire!*

Just think! At the dawn of the last century there were no matches. In those days you lit a pipe with an ember snatched from the open fire with lazy tongs. You had to spin a wheel against jasper with a twisted string, twirl a piston in a cylinder to force heat out of compressed air, or strike a spark from flint with a piece of steel. Many Indian tribes made fire by friction with the twirled stick, with the pump-drill, or with jasper. The Eskimo produced it by rotating a wooden spindle with bow-drill and thong, while the barbaric Polynesian rubbed one stick diagonally against another.

All these early methods of kindling a fire we shall pass over —all except one, the Old Tinder Box, for centuries and centuries the best and easiest method of starting fire; the Old Tinder Box that rested on the mantel over the great stone fireplace of our grandparents—the Tinder Box of colonial days, of the middle ages, yes, and even back to the days of ancient Rome, Greece and Babylon. Tonight we shall perform an old, old experiment, one that dates back thousands of years. And let us examine an old tinder box and see what it contains. We open a metal box of brass or iron, and what do we find? Only a fragment of a hard rock, flint, a few charred bits of cloth, a piece of steel, and perhaps some wood splints tipped with sulphur.

And now I want you to kindle a fire by this famous old method, with a flint and steel. Only we will go the ancients one better. Instead of using flint, we will use any piece of hard stone, such as granite or quartz, or even a cobble-stone. All ready! Take the old cotton handkerchief. Tear it into four pieces, quarters. Now take the two tin plates—pie plates. Set one plate in front of you and have the other ready to use. Pick up one of the pieces of cloth and hold it in your fingers. Light the cloth with a match. Let it burn for a few moments, until it is completely charred, black all over. Careful! Don't burn your fingers or clothing. Now, before the cloth is all burned, drop it into the tin plate before you. Pick up the other of the tin plates. Lay it over this plate carefully. You see the fire is put out—extinguished —and you have a piece of black or charred cotton, called tinder. Pick up the tinder carefully and lay it aside. Now burn another piece of the cotton handkerchief in the same way. Hold it in your fingers—light it—let it burn—until black—drop it into one tin plate—cover with the other plate to put out the flames. You have two pieces of charred cloth or tinder.

Take the sheet of a newspaper. Tear it in halves. Fold the paper—fold it over two or three times. Lay the paper on the table before you. Now place the two pieces of charred black cloth, or tinder, on the paper. Press down on the tinder with your fingers to make it lie flat. You have a hard stone—quartz or granite—haven't you—and a large knife? Well, pick up the stone in one hand and the knife in the other hand

—grasp the stone firmly. Now let us practice a few moments. Strike the stone a quick, hard blow with the edge of the knife, a glancing blow. See the sparks? You are knocking off bits of red-hot steel—heated red-hot by friction with the stone. You know you rub your hands together to warm them, or perhaps you have burned out your automobile brakes on a steep hill. Friction produces heat. Well, how about it? Are you knocking off good sparks? Keep trying. Strike the stone a quick, glancing blow with the edge of the knife. That's good! You ought to see my sparks. They are very pretty. Now we are ready to kindle the fire. Hold the stone just above the black cloth or tinder—three or four inches above it. Strike hard—a quick, glancing blow—watch the tinder. See, one of the sparks has landed on the charred cloth and you see a bright spot on the tinder. You can see the tinder glowing—you have ignited it with the spark. Now pick up the paper and tinder carefully. Partly fold the paper around the tinder, like a cup, and blow on the glowing spark—gently at first—now a little harder—now hard—blow hard—see the tinder and paper burst into flame. You have kindled a fire just as your grandparents used to do, with a flint and steel. Isn't that a pretty experiment?

Will you write and tell me about it? Say, how would you like to use this method all the time? I think you will agree that matches are easier to use—they are far more convenient. And yet matches have been known less than one hundred years. The old white phosphorus friction match was invented in 1827. Perhaps some of you remember the so-called sulphur match of twenty years ago, with its slow action and choking fumes. The use of these matches was stopped in 1913 by a prohibitive tax—white phosphorus is a deadly poison and the fumes affect the bones of the face, causing terrible sores. Today we use two kinds of matches—the common "Strike Anywhere" match and the Safety Match. In making the "Strike Anywhere" match, the wooden splint is first soaked with melted paraffin and then dipped into a paste of glue and some oxidizing agent like red lead or potassium chlorate. For the tip of the match a chemical with a low kindling temperature, called phosphorus sesquisulfid, is used. Light a common match and watch it burn. See. You produce friction by scratching

it on a rough surface. The friction generates enough heat to raise the tip—phosphorus sesquisulfid—to its kindling temperature, the potassium chlorate helps to furnish oxygen which makes it burn faster. The vigorous burning of the tip raises the paraffin to its kindling temperature. Interesting, isn't it? Take one of your safety matches—scratch it on the box. The match lights, doesn't it? But you need the box to scratch it on. Isn't that so? Look at the tip of a safety match. It consists of glue, antimony trisulfid and an oxidizing agent like potassium chlorate. Look at the box. Here you find a layer of red phosphorus, powdered glass and glue. Friction with the powdered glass ignites particles of the red phosphorus, which produces sufficient heat to ignite the antimony trisulfid —which, in turn, burns and raises the paper or wooden match to its kindling temperature. And all this is made possible because different substances start to burn at different temperatures. Some substances have lower kindling temperatures than others. Well, class. I think this is enough for one lesson. You are dismissed. Good night.

VI. How to Make Water Boil on Ice*

Have the following articles ready on your table: 1. A piece of cardboard, 4 inches square. 2. A candle; get a good one. 3. A few matches. 4. A bowl of snow or cracked ice. 5. An old towel. 6. A hairpin or piece of wire 6 inches long. 7. A medicine vial with a tight-fitting stopper.

Good evening, fellow scientists. Say, I forgot to tell you, you will need a glass of water for the experiment tonight. Go and get a glass of water. Put it on the table with your other articles. I'll wait a minute. And let me take this occasion to wish all of you a Happy New Year. May the coming year bring you joy and prosperity. And let me thank you for the many excellent letters and papers you sent during the past week. Splendid. Keep up the good work. Let me tell you about our next science lesson, on Monday, January 10th. The subject is, "Jack Frost and His Funny Tricks." Have your pencil and paper ready. You will need the following articles. Write them down.

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* Radio Science Lesson given at Big Brother Club hour of WEEI, December 27, 1926.

1. An empty teacup. 2. A teacup full of salt, common table salt. 3. An empty bowl. 4. A bowl full of snow or cracked ice. 5. A tablespoon. 6. A medicine vial with a screw top—the same as salicon tablets come in. If you can't get a vial with a screw top, you may use one with a tight-fitting stopper, the same one you are using tonight. Be ready for the next experiment. You will like it.

Well, let's see. What is the subject tonight? Oh, yes,—"Water, Boiling Water." I want to show you how to make water boil on ice. Say, do you know, there is no greater magician in nature than water? Whether we see it as white flakes of snow crystals, as delicate frost pictures on the window pane, as smooth sheets of glistening ice, or as sparkling drops of rain, whether it disappears from sight to become visible again as drifting, fleecy clouds, it is only one of the magic changes that water is always passing through. We are constantly amde aware of its presence when we drink it, cook with it, wash our clothes, take a bath, or warm our homes. And you not only can see water and feel it, and taste it, but you can hear it. Yes, sir! water is a great musician. He plays all sorts of funny instruments. Listen! You hear his music in the drip of the faucet, in the beat of pattering rain drops, in the swirl of dripping snow, in the hiss of escaping steam, in the merry singing of the tea-kettle, in the ripple of the meadow brook, in the rolling surf of sea and lake and shore, or in the resonant thunder of great falls.

But let us pause. I want to show you how to make water boil on ice. All ready? You have a piece of cardboard and a candle. Light your candle. I'll light mine. Tip the burning candle upside down above your cardboard square. Let a few drops of melted paraffine fall on the center of the cardboard. Now, set your candle upright in the melted paraffine. Let it harden. You have a stand, so that the burning candle won't tip over. Now I want you to make a holder for your vial. We are going to boil some water in the little bottle. The holder will protect your fingers, so that you won't burn them. You have a piece of wire or a hairpin, haven't you? If you have a piece of wire, wind it from the center, a couple of turns, around the neck of the vial. Bring the ends of the wire together and twist them. If you have a hairpin, slip it around the neck of the vial like a clamp. Give the ends of the hairpin a twist, so that the vial can't slip out. That's good. Your holder is finished.

Now we are ready to start. Have your bowl of snow and cork stopper handy. Dip the vial into the glass of water. Fill the vial half full of water, yes, a little more than half full, just a little more than half full. Wipe the outside of the vial dry with your rag or towel. Be sure the outside is nice and dry.

Now we are ready to boil the water, and a few more words of caution before we start. Take care to point the mouth of the vial away from your face, so the water won't spurt out and burn you. When the water boils violently I want you to push the cork stopper into the mouth of the vial. And at this point I want you to be careful. Don't hold the vial in the flame after you insert the stopper. On the other hand, if you put the stopper in after the water stops boiling, your experiment will fail. So be careful and follow my directions. All ready? Hold the vial of water, by the piece of wire, in the candle flame, right in the flame. Point the mouth of the vial away from your face. Watch it. Tip the vial sideways a little. Hold it sideways in the flame, and raise it when the water starts to boil. Raise it. Don't let the water spurt out. Raise it above the flame. Keep it boiling quietly. Now pick up the cork stopper. Pick it up with one hand. All ready? This is the hard part of the experiment. Be sure the water is boiling quite fast. Now. Push the cork stopper into the mouth of the vial and take it away from the flame at the same time. Push the stopper in hard. Take the vial away from the flame. There! Is everything all right? I hope you put the stopper in before the water stopped boiling, but, if your experiment doesn't work, you can try again. Take your old towel, wipe the soot off the outside of your vial. Wipe it off clean. Now tip the vial upside down. Hold it upside down. Take a lump of snow. Press it down against the glass vial. Lay the snow on top of the glass against the inverted bottom of the vial. Now watch the space above the water. See! The water is boiling again, boiling on ice. Isn't this a beautiful experiment? See! The water keeps on boiling, boiling fast, as long as you press snow against the vial. Is the water hot now? No. You can hold the vial of boiling water in your hand, can't you? It doesn't burn you, does it? The boiling water isn't very hot, is it? It is only a little more than lukewarm.

Why does water boil at different temperatures? Look inside your little vial. Right there Dame Nature is revealing the wonderful secret. See those bubbles? They are filled with steam,—water vapor. Now, do you see that space above the water in the vial? When the bubbles from the boiling water burst, the steam escapes and fills the space above the water. This causes pressure. The steam takes up room, space, and pushes down on the surface of the water, causing the bubbles of steam to collapse, and boiling ceases. Now put another lump of snow on the vial. The water starts to boil again. Why? The cold snow condenses the steam in that space in the top of your vial. The steam is changed back to water—to a liquid which takes up less room. Hence the condensation of steam produces a partial vacuum above the water in your vial. In other words, the pressure is reduced, which allows the bubbles of water vapor to form at a lower temperature—so that even warm water will boil violently. If you don't believe what I tell you, try to pull out the cork stopper. Ah! It sticks, doesn't it? Hard to pull it out. Why? Why, you are pulling against an outside atmospheric pressure of about 14.7 pounds per square inch.

And so you have learned that boiling depends on air pressure. Increase the pressure of air on the surface of a liquid and it boils at a higher temperature. Decrease the air pressure and you lower the boiling point. This explains how sugars and syrups can be boiled in vacuum pans at low temperature, to prevent burning. It explains the use of pressure cookers in thousands of homes and restaurants. You simply put your meat or vegetables into a strong kettle, clamp down the cover, and cook them within a few minutes. Normal air pressure is 14.7 pounds per square inch. At this pressure water boils at a temperature of 212° F. Increase the pressure to 52 pounds and water boils at 284° F. Increase the pressure to 163 pounds and it boils at 365° F. So you can make boiling water as hot as you want, simply by increasing the pressure.

Say, do you know this? Boiling water is hotter in some places than others? You can boil potatoes quicker in Boston or Portland than in Greenfield or Bangor. The temperature of boiling water depends upon elevation—height above sea level. At sea level water boils at 212° F., at 9,000 feet eleva-

tion the boiling point drops to 195°, at 18,000 feet to 178°, at 27,000 feet to 162°, and at 36,000 feet elevation the temperature of boiling water drops way down to 145 degrees. For every 900 feet of elevation the temperature of boiling water drops 1.66° F. This explains why it takes twice as long to cook potatoes in Cripple Creek, Colorado, as it does here in Boston; while on some high mountains, like Mt. Everest, you would be unable even to cook eggs in boiling water.

Listen! Here is another interesting fact. Do you know that the atmospheric pressure, as indicated by the barometer, changes from day to day? During fair weather air is heavier than during storms. Air weighs less when it rains or snows. This constant change affects the temperature of boiling water—in fact, when the barometer drops one inch, the temperature of boiling water drops nearly two degrees; when the barometer goes up an inch, boiling water is hotter by nearly two degrees. This explains why you can cook potatoes quicker on some days than on others. It explains why it takes longer to cook potatoes during storms, and why they cook quicker on fair days.

VII. Jack Frost and His Funny Tricks*

Place a small table near your radio set. Have the following articles ready on the table: 1. Two teacups—have one full of common table salt. 2. Two large bowls—have one full of snow or cracked ice. 3. A tablespoon. 4. A glass of water. 5. A medicine vial with a screw top—same as salicon tablets come in. 6. A thermometer, if you can get one.

Br-r-r-r! here somes Jack Frost, dressed in a coat of snowy white, sparkling with a myriad crystal gems, with breath you can see, and frigid touch that sends shivers up and down your spine—Jack Frost, king of winter, ruler supreme, holding undisputed sway from the mountains of Tennessee and the rolling prairies of Kansas to the silent forests of Maine and bleak tundras of the frozen north country. Jack Frost, disliked by many and feared, who, when first they feel his icy breath, huddle up to the fire or run away to warmer climes.

But really, Jack Frost isn't such a bad old fellow: he expands your lungs with fresh cold air, he paints your cheeks with the roses of health, he brings you all the exhilarating sports of winter: skiing, sliding, skating, tobogganing, snow-

* Radio Science Lesson given at Big Brother Club hour at WEEI, January 10, 1927.

shoeing and hockey. All this and more, for he covers Dame Nature with his snowy mantle to protect her and keep her warm —giving thereby promise of another springtime awakening, when buds will open, leaves unfold, tender shoots spring up, and the fragrant wild flower will again expand its delicate petals. Jack Frost, Dame Nature's guardian, who watches and protects her during her long winter's sleep.

But look closer. Do you see Jack Frost in that bowl of snow on your table? There he is. And see, he has a bag of funny tricks over one shoulder. Whisper to him. Ask the clever old fellow to open his bag and let you peek inside. What does he say? Yes? Splendid! Now we will find out lots of interesting things. All ready? Take that little bottle you have, the medicine vial. Dip it into a glass of water. Fill the vial full of water, brimming full. Now screw on the cover, or if you have a cork stopper instead, push the stopper into the mouth of the vial as tight as you can. Now measure out three cupfuls of snow—three cups of snow—dump the snow into the empty bowl. I'll do the same. You have a cupful of salt. Isn't that so? All right. Pour the cupful of salt over the snow in the same bowl. With your tablespoon stir the salt and snow together—stir fast—the salt and snow must be well mixed, with no lumps. Is your mixture ready? Mine is. Now, take your vial full of water—dig a hole in the center of the snow-and-salt mixture—drop the vial of water into the hole, and fill it up again. Bury the vial of water in the snow-salt mixture—pack the snow around the vial. Be sure it is completely buried. Now let it set for several minutes. In the meantime, let us take another peek into Jack Frost's bag of tricks. Say, I'll tell you a little secret. Jack Frost doesn't like to have you squeeze him. He is not very keen about such demonstrations of affection. You have some snow left in your bowl? All right. Take a handful of this snow. Make a snowball. Squeeze it hard. See! The snow melts. Release the pressure. See! The snowball becomes solid. The water freezes, changes to ice again. What's that? The heat of your hand melts the snow. Oh, no! Your hand doesn't do it. Your hand doesn't give off heat fast enough to melt the snow as quickly as that. It is pressure that does the trick. Pressure causes snow and ice to melt by lowering the freezing point.

A pressure of 1850 pounds per square inch lowers the freezing point 1.8 degrees F. This explains why you can make snowballs hard by squeezing them and suddenly releasing the pressure. It explains why you can skate so fast and easily on smooth ice. The pressure of your skates melts the ice under them if it isn't too cold, and makes a shallow groove filled with water, so that you really skate on water, on a thin film of water. Then again, water makes the ice slippery, so you can skate fast and the shallow groove helps to steady you.

Say, take a look at your bowl containing the ice and salt mixture. Look at the outside of the bowl. See those pretty pictures: feathery ferns, graceful fir trees, fan-like palms, drooping sprays of birch and balsam. Didn't you know that Jack Frost is a clever artist? Oh, yes. Look at the window-pane at home on some cold morning, and there you will find plenty of evidence of his skillful handiwork. The delicate pictures on your bowl are painted with crystals, beautiful ice crystals—and these crystals come from the air around the bowl. Herein we observe the secret of all forms of precipitation: fog, clouds, dew, hail and snow. Air always contains more or less of invisible water vapor—water in the state of a gas—an invisible gas. Now the amount or quantity of water vapor air can hold varies at different temperatures. Warm air can hold much more water in the form of a vapor or gas than cold air. And so, as is the case here, when the air is gradually cooled it capacity to hold water vapor becomes less and less, until the point of saturation is reached. Further cooling causes some of the invisible water to come out of the air, to condense into the tiny droplets of fog and cloud, into the larger drops of rain, or if the vapor condenses below the freezing point, into the beautiful six-sided crystals—snow flakes. The frost on the outside of your bowl is really snow—only the crystals were formed slowly into delicate and realistic frost pictures.

And now, I want you to look inside the bowl. Do you see? Much of the snow and salt has melted, changed to salt water. Can you tell me why the snow melted so quickly? That's it. The salt did the trick. Salt melts snow and ice because it makes the freezing point lower, in other words it lowers the melting point below 32 degrees F. This explains why we put

salt on sidewalks and car-tracks in winter. Salt melts the snow and ice by lowering the temperature at which water ordinarily freezes.

Now we come to the interesting part of our experiment. I hope you were able to get a thermometer. Just stick the bulb of your thermometer down into the melting mixture of snow and ice in the bowl. Watch the mercury column. Isn't that remarkable? See, it drops way down almost to zero—yes, my thermometer reads two degrees below zero, 34 degrees below freezing. If you don't believe me, stick your fingrs into the mixture. Isn't it cold? Tell me now. What makes the mixture so cold? The salt again. When the salt melts, goes into solution, heat is absorbed. When a salt dissolves in water lots of heat is used up, absorbed. To convince yourself of this fact, take two glasses of water when you have an opportunity. Put a handful of salt into one glass of water and stir it up. Now stick your fingers into each glass in turn. You will discover that the salt water is much colder. This effect is so pronounced that you can make ice very easily by dissolving salt in water. Heat absorbed by the salt when it goes into solution lowers the temperature below the freezing point. This explains why you use salt when you make ice cream, and it explains why your mixture of salt and ice in the bowl is so cold. Say, if you want to freeze your ice cream quickly buy calcium chloride instead of common table salt. A mixture of seven parts snow and three parts calcium chloride by weight will produce a temperature of 65 degrees below freezing—and with another salt, ammonium nitrate, you don't need any snow or ice, you can freeze your ice cream simply by dissolving the ammonium nitrate in water. Unfortunately this process is rather expensive.

Oh, say. I almost forgot about that vial of water we buried in the bowl several minutes ago. Dig the little bottle out of the mixture of snow and salt. Pick up the vial. Ah, you are surprised! The vial is broken, the glass cracked into a hundred pieces. And see, you have a lump of ice. The water you put into the bottle is frozen into a solid lump of ice. Interesting, isn't it? But tell me—what broke the bottle? What shattered the glass into a hundred pieces? Ah! I hear your answer—Expansion. When water freezes, expansion takes place—the ice takes up more space. When the vial

of water changed to ice—the ice needed more room; so it pushed against the inside of the vial and shattered the glass. A cubic foot of water will give you 1.09 cubic feet of ice—almost one-tenth—ten per cent more. If you put ten quarts of water into a pail and let it freeze solid, you will have almost eleven quarts of ice. And this is one of Jack Frost's tricks. He can give to seemingly harmless and peaceful water, the power of a mighty giant—the power to exert a pressure of tons and tons— a pressure so enormous that it easily ruins your automobile radiator, bursts water and waste pipes in your home, or even splits huge rocks from the sides of mountains.

Say! Can you tell me this? Is freezing a warming or cooling process? Ha! ha! I caught you that time. I heard some of you say freezing is a cooling process. You are wrong. When water freezes heat is given off. Years ago, and even today, farmers put tubs of water in the cellars on cold nights, to protect the vegetables. The freezing tubs of water give off heat and keep the vegetables warm. When a gallon of water changes to ice enough heat is given off to raise the temperature of a gallon of water 144° F., and that is sufficient heat to raise the temperature of a gallon of water from 68° to 212° F., or to heat it to the boiling point. Just think what happens when a big lake freezes. Enough heat is wasted to heat thousands of homes like yours and mine all winter—and cook all our food at the same time. Too bad we can't save it. But then, Jack Erost is a wasteful old fellow in many ways.

One more question before I stop. Why do you use ice in your refrigerator? Why does ice keep food cold? Because ice is cold? No, that is not correct. Ice isn't any colder than ice water—both are at 32° F. Ice water is just as cold as ice —but you wouldn't try to cool your refrigerator with ice water—ice water would be of very little value for this purpose. Listen! Ice isn't any colder than ice water, but it makes other things colder—lots colder—you get as much cold out of a pound of ice as you would out of 144 pounds, 18 gallons of ice water. Ice makes things cold because it absorbs so much heat when it melts. A pound of ice absorbs enough heat when it melts to lower the temperature of a pint of water 144° F., and queer as it may seem, melting ice absorbs lots of heat

without getting any hotter—for this reason we call it hidden or latent heat.

Well, I guess I have talked long enough. Tell me how you liked this experiment, and don't forget two weeks from tonight, Monday, January 24. I have a pleasant surprise for you. Watch out!

VIII. A Candle and How it Burns*

MATERIALS—Two drinking glasses, two short candles, two saucers, box of matches. Have one saucer half-full of water.

SUMMARY OF LESSON DEVELOPMENT.

1. What is the flame of a candle?
2. How does paraffin change when it burns?
3. What are the parts of a candle flame?
4. Does a burning candle need oxygen?
5. What is the black stuff in a candle flame?
6. What happens to carbon when it burns?
7. Is the candle flame wet or dry?
8. Why is the burning candle a danger signal?
9. How are you like the flame of a candle?

Good evening, young folks. Everything ready for your radio science lesson. My! what a big laboratory. Miles long and miles wide. And look at the size of my class. Thousands of waiting girls and boys. And out there in space I see familiar faces. Some of the thousands who have, in past years, sat in my own classroom—to whom again I extend an invisible hand of welcome. Hullo! girls and boys. Come in. Join my class again. The lesson is a simple one, and I believe appropriate for this evening of Washington's birthday. *It's about a candle flame.* And you are to be the scientist; to see and discover for yourself many of nature's wonderful truths. Every question I ask will be a challenge, a challenge to you—a challenge to your ability to see straight and think straight. You will find the answers in the experiments we do. At the end of the lesson write the answers and send your letter to Big Brother Club, Station WEEI. Give your name, age, school and grade. And a word of caution before we begin. Look out for matches —especially the burnt ones. Have your parents supervise the experiments. Be careful. Let me see now if I have everything ready? Yes, here are my candles, saucers, drinking glasses and matches. And one saucer is half full of water.

* Radio Science Lesson given at Big Brother Club hour of WEEI, February 22, 1926.

Wait a moment. I want to put one glass on the window-sill, to keep it cool. You do the same thing. That's good.

Are you ready? Light one of your candles. I'll light one of mine. Don't blow out the match. Wait just a moment. Now, with a vigorous "puff," blow out the candle, and hold the burning match just above the wick. There! What happens? Be quick. Light a second match. Blow out the candle again and hold the burning match above the wick. Try it with me several times. How far away can you light your candle? I can light mine an inch above the wick. Look at that. See the smoke, and see the flame travel back like a lightning flash. Tell me now. What is the flame of a candle? What is the flame of any fuel: wood, coal, paper, kerosene, or oil? Burning gas, you say. That is right. It is burning gas.

Let us take up the next question. *How does paraffin change when it burns?* Look at the candle. Made of solid paraffin, isn't it? Now look at the top of the burning candle? See that hollow cup? What is it filled with? Yes, liquid paraffin. Look at the flame. What is that? Burning gas? Right. What changes paraffin from a solid to a liquid? From a liquid to a gas? Isn't it heat? Anne tell me. Is paraffin the only substance that changes this way?

How about water? What is the water you drink? What is ice? What is steam? And what changes water from a solid to a gas? It's the same agile magician—heat.

Are you ready for another experiment? Well then, look closely at the flame of your candle. How many parts can you see? Only three? All right. We'll let it go at that. Look at the pretty blue cup at the bottom. What is it? You don't know? Why, that is the lightest gas in the world, the gas you use in balloons. You swallow lots of it in every glass of water you drink. It helps make your automobile go. You see it in the flame of every gas-burner of your kitchen range. That pretty blue cup is burning hydrogen. Hot, you say? Put your finger near it. It certainly is a hot flame—and clear—it never smokes. Now look at the center of the candle flame. See that dark, cone-shaped region? What is that? No answer. Well, let's see if we can find out? Take a match. Hold it horizontal, side-ways, by both ends. Now pass the

center of the match back and forth throughout the dark cone. A little slower. Watch the wood start to burn. Where does it catch fire first? At the edges of the flame, doesn't it? Tell me then, is the dark cone hot or cool? What, cool? Yes. And say, is this cone-shaped region really dark? Take one of your saucers. Hold it just back of the candle flame. Bend over, so your eyes are level with the top of the candle. There. Now look through the central cone, at the saucer. Do you see? The central cone is not dark at all. It is colorless—transparent. And what do you think this transparent region is? Unburned gas? Certainly. It is Dame Nature's gas factory, where she cooks up gases and stores them away until she wants to use them. Look at the upper part of the flame. What color is it? Bright yellow? Correct. And what does this part of the candle flame consist of? You ought to know from the results of our first experiment. Right. It consists of burning gas—the same gas that comes from the little gas factory below.

All ready? Next experiment. *Does a burning candle need oxygen?* Light one of your candles. Set it carefully in the saucer of water. Don't let it go out. Now. Take one of the drinking glasses. Turn it upside down. Bring the mouth of the glass down over the burning candle. Let the glass rest on the bottom of the saucer. Be sure the mouth of the glass is under water. Watch the candle flame. See? It goes out, doesn't it? And look at the water. What happens? It rises inside the glass. How high does it rise? Pretty experiment. Tell me, why did the candle flame go out? Certainly. The burning candle must have used up part of the air in the glass. And what do we call this part of the air? Think a moment. Yes, oxygen, the most common, the most wonderful, and the most essential of all gases—the gas that keeps the fires burning in your stoves, heaters, and even in your own bodies, to supply heat and energy to do your daily work. Is air all oxygen? One hundred per cent oxygen? Think it over.

STOP! Next experiment. *What is the black stuff in a candle flame?* Light a candle again. Take the empty saucer. Hold the bottom of the saucer in the flame of the candle. Right in the flame. Be sure the flame touches the bottom of the saucer. Watch. See the black stuff. What is it? Yes, it is

carbon. And where does the carbon come from? Think. Ah, you have it right. Black carbon comes from the white paraffin of the candle. Strange, you say? True; but this is only one of the many wonder stunts Dame Nature performs. We call it a chemical change. And now look at the candle flame. Do you see any black carbon given off? No. Not a bit. Then why did the flame deposit carbon on the saucer? Yes, the saucer shuts off some of the air—and you are right—the saucer cools the flame. Black soot or carbon always forms when you exclude air or cool a fire. It is a product of incomplete burning or combustion. That's why carbon chokes your automobile cylinders in winter, and that is why the inside of your stoves and chimneys are covered with soot, and that is why the bottom of your kettles are black. Look at the candle flame now. It doesn't give off any black soot, does it? No. Every tiny particle of carbon grabs hold of two tiny particles of oxygen and changes to the colorless, invisible gas, carbon dioxide. In complete combustion the carbon in fuels always unites with oxygen to form this gas.

Are you ready for the next experiment? All ready? Did you put one drinking glass on the window-sill to keep it cool? Well, get this glass. I'll get mine. Relight a candle. Tip the glass upside down. Look at the inside of the glass. Dry, isn't it? Now hold the bottom of the glass just over the candle flame. Watch the inside. What do you see? Moisture? Good. Rub some on your finger. Is the inside of the glass wet or dry? Yes, it is wet. Where does the water come from? The candle flame? Where does the flame get the water. The paraffin? Oh, no, paraffin isn't wet. Do you know what water is composed of? Certainly—hydrogen and oxygen—the two common gases we mentioned before. Now then, where does hydrogen come from? From the paraffin? Right. And where does oxygen come from? From the air around the candle? Right. And what happens to hydrogen and oxygen in the flame? What? They unite. Correct. And what is formed? Water? Good. Tell me then, is the candle flame wet or dry? Yes, it is wet.

Next experiment. *Why is the burning candle a danger signal?* Light a candle. Take a white saucer—the empty one. Hold the bottom of the saucer in the flame—let the flame

touch the bottom. Now lower the saucer slowly until it touches the wick. Don't put out the candle. If it goes out, relight it and try again. Watch the flame. See! It changes from yellow to a deep blue color. What is this blue flame? You don't know? Well, you ought to, for it has a lot to do with your health and safety. That deep blue flame is burning carbon monoxide, the deadly carbon monoxide, the gas that kills so many people. How about that terrible accident in Waverley a few days ago? Did you read about it in the papers? Seven people killed in one home. But where does this deadly gas come from? How is it formed by the burning candle? Lower the saucer over the flame again. How does the saucer affect the supply of air? That's it. Some of the fresh air is shut off—kept away from the flame. How does the saucer affect the temperature of the flame? Does it make the flame hotter or colder? Yes, it cools the flame. And look at that black soot on the bottom of the saucer. Has that anything to do with carbon monoxide? Yes, it has. Carbon monoxide is always formed where there is lots of carbon present. You see the same blue flames when you put fresh coal on the fire. Tell me now, the three common causes for formation of the deadly gas, carbon monoxide. *First.* Right! Lack of air. *Second.* Right! Lack of sufficient heat. *Third.* Right! Too much carbon.

Now we come to the last experiment. *How are you like a burning candle?* Are you made of soot and hydrogen? Do you need fresh air? Are you burning? Do you consume fuel? Do you give off heat? Do you breathe out carbon dioxide? I leave these questions for you to answer.

Remember, now, I want you to write up this science lesson and send in your paper to station WEEI—to Big Brother—I'll promise to look over the papers and tell you the names of those who send in the best written papers—next Monday night. And let us know if you enjoy this kind of a lesson—I'll plan to give you some more if you do. I'll look for those papers. Good night!

Cleveland Schoolmasters Club Committee Report on Science

Ellis C. Persing, Chairman
Cleveland School of Education

When your science committee began their work about three years ago, there were a number of problems relating to science instruction which seemed to claim some study.

The committee was convinced that any problem which it should attempt should be for the promotion of a twelve-year science curriculum, from the Kindergarten through the High School. After a consideration of the many problems, the committee decided to confine their first study to Senior High School science. As you will recall, the first study dealt with the general objectives for General Science, Biology, Chemistry and Physics, and indicated that teachers of these sciences were more interested in science as a specialized subject, as shown by the fact that pupils were found to be more familiar with technical terms than the common terms of the subject-matter. And further there was a lack of agreement between stated aims and what the pupils are actually learning in these sciences. The results of this work seemed also to indicate that chemistry should come in the later years of the high school course. Furthermore, in the organization of the curriculum for the senior high school more consideration should be given to the sequence of the sciences, in order that pupils may not graduate from our high schools without an opportunity to learn the phases of science which are necessary for everyday life.

The next year your committee began a study of science in the elementary school and junior high school. The major part of the work was with the junior high school, since the American Nature Study Society and The Cleveland Elementary Science Committee were at work on the problems of science in the elementary school. The Nature Study Society has published the results of the study in the First Yearbook. The Cleveland Elementary Science Committee consists of twenty-six persons,—principals, teachers, and members of the School of Education staff. This committee has undertaken the task of stating objectives in science from the Kindergarten through the sixth grade. These objectives have been written in a course of study and tried for more than a year in the Cleveland schools. During this time the committee has worked

with the teachers in the field to get their help in revising the course. These suggestions are now being incorporated in the course in elementary science for next year. In addition to this, the Cleveland Elementary Science Committee has undertaken a study to determine the objectives in elementary science from a study of pupils' questions.

The complete report of your committee for last year was published in the Journal of Chemical Education, Vol. 3, No. 3, March, 1926. The fact that out of 103 schools answering the questionnaire, 54 require science in the seventh year, 71 require science in the eighth year, and 54 require science in the ninth year, indicates that science has become established in the three years of the junior high school. This, you will see makes the science course continuous through the elementary school, junior high school, and senior high school.

With the work of reorganization going on in the elementary school and the senior high school, your committee decided to work on the problem of what science to teach in the three years of the junior high school. Since it would be impossible to complete this study in one year, your committee wishes at this time to submit an outline of procedure for the work which is being carried on in connection with sub-committees.

While the present objectives of junior high schools have been determined by comparatively careful analyses of social needs, they are not adequate. Hopkins in Denver analyzed the content of periodicals. Washburne analyzed children's questions. The same procedure was followed by Pollock in Columbus and by Caldwell and Eikenberry.

Your committee proposes to make four parallel studies, the results of which taken together would be an advance over any previous analysis of junior high school objectives in science. The procedure includes first, an analysis of present objectives as given in textbooks, courses of study, and curriculum investigations; second, an analysis of the questions and activities of children; third, an analysis of the questions in science asked by adults; fourth, a systematic analysis of the environment. The objectives obtained in any one study will be checked against the objectives obtained in other studies. In this way adequate attention will be given to existing materials, pupils' interests and activities, and adult interests. The analysis of the environment should reveal any important elements which have been neglected by other studies.

Outlook for Elementary Science and Nature Study

ELLIS C. PERSING
Cleveland School of Education

In connection with curriculum construction work on the new elementary science course for Cleveland schools, a letter was sent to 184 representative schools throughout the country, requesting their course of study in elementary science and nature study. In this way we hoped to ascertain the status of elementary science and nature study in other cities.

The number of replies received was 84. This number was fairly representative of large and small cities, as well as covering most sections of the United States.

The large percentage of cities revising or preparing a new course in elementary science or nature study is gratifying to those working in the science field.

The number of cities with printed or mimeographed courses of study in elementary science and nature study was 26. This added to the number preparing new courses gives a total of 63 cities with definitely planned courses being used or in preparation. Most of the courses in preparation were to be completed during 1926-1927. Therefore it is reasonable to assume that during 1926-1927 about 72 per cent of the cities reporting in this study will be doing definitely planned work in elementary science and nature study.

The number of cities giving attention to elementary science and nature study incidentally is relatively small. For the cities reporting only about .047 per cent teach elementary science and nature study in this way.

TABLE

Number of schools revising or preparing new courses in elementary science and nature study	37
Number of schools with courses of study in elementary science and nature study	26
Number of schools giving attention to elementary science and nature study incidentally	4
Number of schools reporting no course of study in elementary science and nature study	17
Total	84

Internal Stresses in Solids*

The fact that severe internal stresses occur in solids of certain kinds, in consequence of sudden cooling, is well understood in industry and the arts. Iron castings, for example, often have to be turned out with the greatest attention to this feature, because otherwise the stresses that are produced in them through unequal cooling may be great enough to produce subsequent fracture. Moreover, severe stresses are often introduced into materials of various kinds in consequence of working them into special forms; and these stresses may be so great that, although they do not give rise to fracture, they are nevertheless important things to consider when we have to determine the load that some device or structure is capable of safely sustaining.

The process known as "annealing," which usually consists in heating an object up to a rather high termperature and then allowing it to cool very slowly indeed, is often highly important in order to insure reasonable permanence in the object that is undergoing treatment. The idea is, that the heating allows the stresses to relieve themselves in large measure, so that when the object has finally cooled again, it is reasonably free from them.

Solids, such as glass and enamel, which do not "yield" sensibly before rupture when they are exposed to tension, compression or torsion, are specially likely to be under a condition of great internal stress, unless they are carefully annealed after having been strongly heated in the course of manufacture. This is well understood by glass-workers, and they know that window-glass, glassware intended for household use, lamp chimneys, and all other objects that are made of glass, must be thoroughly annealed.

Articles made of glass that has not been thoroughly or properly annealed often break, apparently spontaneously, or at least under conditions that do not suggest any immediate determining cause. In the Home Office of The Travelers, for example, we have had a number of glass inkwells break in this way. As a matter of interest, we illustrate one of them herewith. This particular inkwell went to pieces at noontime on a moderately warm day. It was standing upon a desk and nobody was anywhere near. The only thinkable immediate cause that could have precipitated the explosion

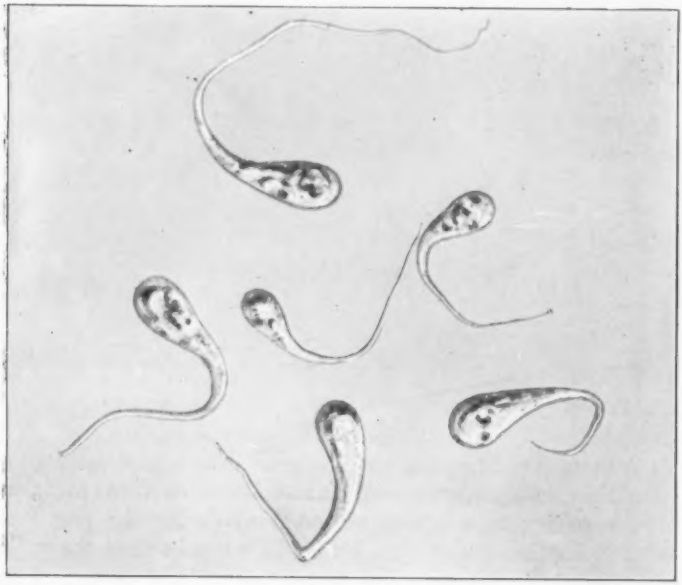
* From "Travelers Standard," courtesy of Travelers Insurance Company.

was a slight draft that came in through a window some ten feet away. This may have modified the stresses in the improperly annealed inkwell sufficiently to precipitate the fracture. It is almost incredible that this could have been the case, because the inkwell must have been exposed to greater chills than this many times. No other cause suggests itself, however. Nobody was injured by the glass fragments in this case.

Fragments of an Ink-well that Burst while standing on a desk in an office.

A more serious example of the spontaneous rupture of glass, doubtless in consequence of internal strains through insufficient or improper annealing, occurred during the past summer in another Connecticut city. This consisted in the explosive fracture of a glass eye that was in place. Some of the fragments were blown out of the eye-socket, but others remained in place and were driven into the lining of the socket and embedded there, so that a surgeon had to work over the patient for something like a full hour before they were all removed. This particular accident, of course, is of an extraordinarily unusual nature, but we mention it because it serves to emphasize the importance of these strains of which we are speaking.

A lecture-room experiment, familiar to old-time students of physics, consisted in exhibiting the destruction of the pear-shaped globules of unannealed glass that are known as "Prince Rupert's drops." The Prince Rupert for whom they are named lived in the seventeenth century, and was Duke of Bavaria and a grandson of James I of England. In his day he was well known for his military activities, but to posterity he is remembered mainly on account of his attainments in science, technology and art. Whether he actually invented the "drops" that go by his name or not, we do not know, but at all events he introduced them into England. They are made by chilling globules of melted glass in such a way that the material, when cooled, will be subject to great internal stresses.



Prince Rupert's Drops. These curious objects are composed of unannealed glass and are subject to severe internal stresses. If the small tip is broken off from one of them, the entire remaining portion of the "drop" will immediately burst into innumerable dust-like particles.

These stresses are sufficiently well balanced for the drop to remain whole under ordinary careful handling, but when the tip end of the little tail that projects from them is broken off, and the balance of the stresses is thereby destroyed, the entire body of the drop immediately flies into incredibly small particles.

Summer Courses in Science

We have received announcements of Science courses for this summer as follows:

University of Chicago, June 18 to July 27, and July 28 to September 2.

The Teaching of General Science	Prof. H. A. Cunningham
Teaching Science in the Schools	Prof. E. R. Downing
Organizing of Elementary Science (Nature Study)	Mr. O. D. Frank
Biology in Secondary Schools	Professor Downing
High School Physics	Mr. A. W. Hurd
High School Chemistry	Professor Cunningham
The Science Curriculum	Professor Downing

Cleveland School of Education, Western Reserve University, June 20 to July 29.

General Science (Physical Science)	Mr. Ellis Pershing
Nature Study for Elementary Science	Mr. Pershing
General Biology	Mr. Persing
The Teaching of Elementary Chemistry	Mr. Hayes

Middlebury College, Vermont, June 29 to August 17.

Biology	Professor S. E. Longwell
Chemistry	

University of Oregon (Eugene), June 20 to July 29.

Botany	Professor J. E. Kirkwood
Chemistry	Professor O. F. Stafford
Physics	Professor A. E. Caswell
Zoölogy	Professor H. B. Yocom

George Peabody College for Teachers, Nashville Tennessee.

Science in the Grades, 4 years credit	Prof. H. A. Webb
General Science in Secondary Schools, 4 years credit	Professor Webb
Materials and Methods for Teaching Chemistry in Teachers Colleges, 4 years credit	Professor Webb
The Teaching of Physics in High Schools, 5 years credit	Mr. Fountain

Massachusetts Institute of Technology, July 5 to August 2.

Methods of Teaching General Science	Mr. Joseph R. Lunt
General Science Laboratory	Mr. Lunt
Methods of Teaching Chemistry in High Schools	Mr. Charles H. Stone

Methods of Teaching Physics in High Schools
Mr. Fred R. Miller
Methods of Teaching General Biology Prof. F. C. Prescott

Columbia University, July 11 to August 19.

Teaching General Science in Secondary Schools
Mr. E. R. Glenn
Organizations of Science in Secondary Schools
Professor S. R. Powers
Organizations of Science in Elementary Schools
Mr. G. S. Craig
Teaching Science in Elementary Schools H. R. Sperry
Special Problems in Science Teaching in Secondary Schools Professor S. R. Powers
Teaching Chemistry in Secondary Schools
Mr. A. I. Lockhart
Teaching Physics in Secondary Schools Mr. E. R. Glenn
Teaching Biological Science in Secondary Schools
Dr. C. W. Finley
Field Studies in Science Dr. C. W. Finley

New York University, July 5 to August 12.

Teaching General Science Mr. Bedford
Teaching Chemistry in High Schools Mr. Bedford
Teaching Physics in High Schools Mr. Bedford
Teaching Biological Science in Secondary Schools
Mr. Wheat

State College, Pennsylvania, July 27 to August 5.

Institute of Chemistry and Physics—Lectures and demonstrations by the country's greatest scientists.

Hampton Institute, First Session, June 15 to July 23.

The Teaching of General Science—Science in the Home
Mr. W. G. Whitman
Teaching of General Physics—Heat, Light and Sound
Mr. W. G. Whitman

Second Session, July 25 to August 27.

The Teaching of General Science—Science in the Community Mr. W. G. Whitman
The Teaching of General Physics—Mechanics, Magnetism and Electricity Mr. W. G. Whitman

University of Wisconsin, June 25 to August 5.

The Teaching of General Science	Prof. Ira C. Davis
The Content of General Science	Prof. Ira C. Davis
The Teaching of Chemistry	Mr. Walton
The Teaching of High School Physics	Mr. Steve

DeVry Summer School of Visual Education, Chicago, June 27 to July 1. Five days free tuition, under staff of experts.

The New Books

Modern Astronomy—Hector MacPherson—196 pages—25 illustrations—Oxford University Press, American Branch.

This book comprises the lectures of the author given in the Thomson Lectures in Natural Science for the session 1925-1926. The scope is indicated by the chapter titles: Introduction; Our Knowledge of the Moon; Our Nearest Star—the Sun; The Dwarf Planets; The Giant Planets; Asteroids, Comets and Meteors; The Stars; New Stars and Nebulae; Cosmology; and Cosmogony. This is an exceedingly fine treatment for the teacher and even advanced high school students can get much from it. It presents a brief historical view and omits the mechanics of our system, but brings important theories right down to their present status.

A Girl's Problem in Home Economics—Mabel B. Trilling and Florence Williams—314 pages—148 illustrations—J. B. Lippincott Co.

This is a text for Junior High or first year in Senior High schools. Subject matter treated is that which is likely to be met in the home life of girls in these grades. The girl's own room, her clothes and various activities which are to her special interests are among the topics treated. The lessons are on the problem-solving basis. The action of the sewing machine is explained, and the use of color in the illustrations adds much to the effectiveness of them. Various clothes making problems are undertaken, the care of clothing, the use of labor savers and room furnishing are among the many topics which are well treated.

1926 Year-Book of Southwestern Educational Research and Guidance Association—48 pages—Research Service Company, Los Angeles, Cal.

The Year-Book contains some of the addresses given at their annual meeting. Some of the papers are: psychology of learning; shall the results of intelligence tests be reported to parents; research in relation to child training; factors affecting the development of tests for use in vocational guidance; diagnostic tests in school subjects; the new age and education. Membership in the association ($1.00 a year) entitles members to one copy of the year book.

Economics of the Science of Business—D. O. Kinsmen—366 pages—$1.72—Ginn and Company.

This is a high school text which will help fit our students for the business world. The divisions of the book are:

1. Wants and Wealth 2. Production 3. Exchange 4. Distribution 5. Consumption 6. The State, its Functions, and its Support

Elements of General Zoology—William J. Dakin—496 pages—252 illustrations—$4.00—Oxford University Press, American Branch, New York City.

In this elementary textbook on animal biology, the author aims while undertaking the study of structure to bring out the inter-relation of function and so has adopted a new method of approach to this subject. Following are some of the chapter headings: Introduction to the Phylum Protozon; Composition of the Animal Body and of Food; Nutrition; Respiration; The Blood and Circulation; Temperature and Animal Life; The Skeleton; Muscular Activity; The Cell; Nervous System; Sense Organs; Excretion; Symbiosis; Reproduction; Evolution and Heredity; General Instructions for Laboratory Work.

Our Environment—George C. Wood and Harry A. Carpenter—27 + 704 + 32 pages—355 illustrations—Allyn and Bacon.

This is an exceptionally fine text. It is organized around the environment, and is divided into five parts as follows:

1. Environment, Energy and Work. 2. The Work of the Factors of our Environment. 3. The Importance of Industry. 4. The Source of all Energy. 5. Storage and Use of Solar Energy by Living Things. 6. The Work and Care of the Human Body. 7. The Work of Protecting the Human Body from Dangers in its environment. 8. The Work of Improving Living Things.

There are special features in this text which are teaching helps. Some of these are an introduction chat at the beginning of each chapter and practical questions on the work of the chapter. There are problems outlined and summaries. Twenty-eight key demonstrations are given. These are considered fundamental, and are to be entered in the pupil's science notebook. The book is intended for the ninth grade of the Junior High School or the first year of the Senior High School. It covers the work outlined in the New York State Syllabus in general science.

Columbia Research Bureau Tests—Physics.

Columbia Research Bureau Tests—Plane Geometry—World Book Co.

These tests, prepared as a part of the work of the Bureau of Collegiate Educational Research of Columbia University, should aid materially in establishing and maintaining comparable standards of achievement in high schools, in reducing local high school standards to a common denominator for purposes of college entrance, in making the basis for college entrance credit actual achievement rather than time serving, and in reducing failures and maladjustments in college through correct placement according to ability.

Correlated Handwriting Compendiums—Frank N. Freeman—Grades 1 to 6—Zaner-Bloser Co., Columbus.

This series consists of an entirely new set of Compendiums and Teachers' Manuals. It emphasizes the correlation between practice in writing and the use of writing in the other subjects of the school and in activities outside the school. The course is graded in accordance with the psychology of the child's development and the modern educational practice. This material is so chosen that writing difficulties are few at the beginning and increase gradually, while the writing and the materials used show the same graduation. Throughout the course the emphasis is upon the actual writing, but sufficient formal drill is introduced to give the child the training in drill which he needs. Teachers' Manuals One to Six provide definite weekly outlines and suggestions for each grade and a Complete Teachers' Manual comprising Manuals One to Six is provided to meet the needs of teachers who have more than one grade in a room.

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This book has been prepared particularly for use with Hunter and Whitman's *Civic Science in Home and Community.* It also covers the field of the two single volumes by these authors: *Civic Science in the Home* and *Civic Science in the Community.*

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NEW YORK CINCINNATI CHICAGO BOSTON ATLANTA

Makers of Science: Electricity and Magnetism—D. M. Turner—184 pages—65 illustrations—$2.50—Oxford University, American Branch, N. Y. C.

This volume gives the main developments of electrical science to the end of the 19th century. It is written for the general reader, and young student. The following are chapter titles: early Speculation; Electrostatics in the 18th Century; The Electric Current; Electromagnetism; Discovery of Electromagnetic Induction; Electric Measurements; Electrical Theory; Electrolysis; The Conduction of Electricity through Gases; Electrical Constitution of Matter.

An Introduction to Biology—A. C. Kinsey—558 pages—430 illustrations—J. B. Lippincott Company.

This is a biology text for high school students. It is a unified and synthetic biology in which the emphasis is placed upon phenomena common to both plants and animals. It includes certain phases of ecology, an extended treatment of distributional biology and behavior. It is divided into seven parts:

1. Taxonomy. 2. Morphology. 3. Physiology. 4. Genetics. 5. Ecology. 6. Distributional Biology. 7. Behavior.

The Polarimeter—D. V. Saunders—30 pages—illustrated—1s. 7p. postpaid—Adam Hilger, Ltd., 24 Rochester Place, London.

This is a one-hour lecture and includes reproductions of the 15 lantern slides used by the author. It covers the history, development, and important industrial applications of the polarimeter.

The Development and Present Position of Chemical Analysis by Emission Spectra—F. Twyman, F. R. S.—43 pages—illustrated—2s. 8p. postpaid—Adam Hilger, Ltd., London.

This little book contains two lectures:

1. Discovery and Development of Spectrum Analysis.
2. Producing, Observing, and Photographing Spectra.

These will be of special interest to chemistry teachers. The publisher can also supply the 20 lantern slides reproduced in the book at 35 shillings per set.

Tests and Measurements in High School Instruction—G. M. Ruch and G. D. Stoddard—edited by Lewis M. Terman—381 pages—$2.20—World Book Company.

This volume contains the information regarding the current practices in educational measurement as it applies to high schools. Historical facts are included in Part 1. Part 2 presents the more important published measurements useful to high school teachers. Part 3 discusses informal examination methods. Part 4 explains the construction of educational and mental tests.

Physics in Industry—Walter A. Makower and Bernard A. Keen—63 pages—17 figures—$1.00—Oxford University Press, American Branch.

This is Volume 4 of the series and includes lectures, VIII "Physics in the Rubber Industry," and IX "The Physicist in Agriculture." They are technical descriptions and do not lend themselves to elementary pupil study.

Applied Chemistry Experiment Sheets—Martin Mendel—75 experiments—Globe Book Company.

This gives the usual experiments for elementary chemistry but with a little emphasis upon the practical application of metals. It is a bound manual with the right-hand pages left blank for the pupil's notes.

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Problems of Modern Physics—H. A. Lorentz—Edited by H. Bateman—312 pages—50 diagrams—$3.60—Ginn & Company.

This book contains the lectures which Professor Lorentz delivered at the California Institute of Technology in 1922. These lectures give an introduction to the problems upon which physicists are now concentrating their efforts. The book is not one for the elementary scientists, but for advanced students. Among the topics treated are: Propagation and Waves of Light; Flow of Energy in a Beam of Light; Field Equations of the Electron Theory; Reaction of Radiation on a Moving Electron; The Sun's Apparent Boundary; Scattering of Roentgen Rays; Electromotive Forces; Principles of the Theory of Special Relativity; Structure of Electrons; Interference and the Quantum Theory; The Zeeman Effect.

Elements of Chemistry—H. N. Holmes and L. W. Mattern—519 pages—257 illustrations—The Macmillan Company.

The authors start out in this volume to "capture the interest and attention and then to lead the class on to scientific thinking." They have succeeded exceptionally well in developing this plan. There are many striking illustrations which emphasize the industrial importance of chemistry. The ground covered is that of the usual high school course. A good list of exercises closes each chapter.

The Millennium and Medical Science—D. N. Schaffer—371 pages—10 illustrations—$2—Wilbur Needham, Evanston, Illinois.

This book is divided into three parts: I. Object lessons in health and disease. II. Nature's work and organ transplantation. III. Science triumphant and true practice. The whole is an interesting story of life from a viewpoint of sociology.

ANOTHER SUPPLEMENTARY SCIENCE LEAFLET FOR PUPILS

In addition to the three supplementary science sheets for pupils' use listed on page 218, General Science Quarterly for March, we now have a fourth, edited by Professor Ellis Persing of the Cleveland School of Education.

School Service Bulletin, Science and Invention—230 Fifth Avenue, New York City—Monthly—15c a year.

This is a six-page folder on the same pattern as "Science Classroom." It gives references to current science topics in Science and Invention, and Radio News. These are classified and listed under the heads Elementary Science and Nature Study, General Science, Biology, Chemistry, and Physics. Besides these references there are articles, teachers helps, and general references.

Science Articles in Current Periodicals

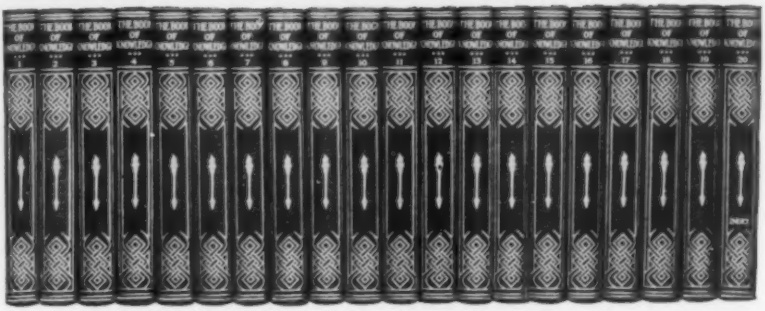
[These classified articles should make valuable supplementary reading for the pupils. In some cases the material is in such form that it would be too difficult for many of the pupils to abstract the matter for themselves. In such cases the article may be read by the teacher and passed on to the pupil in class. Such articles are starred.

AMBER

The Baltic Amber Deposits. Sci. Mo. 24:268, Mar., 1927.

ANESTHESIA

The Discovery of Anesthesia. Sci. Mo. 24:64, Jan., 1927.



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Formation of Moon and Earth. Sci. Mo. 24:15, Jan., 1927.
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New Worlds in the Making. Pop. Mech. 47:626, Apr., 1927.
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How a Self-contained Neighborhood Unit Might be Planned. Amer. City 36:287, Mar., 1927.

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Raising a Fleet from "Davy Jones's Locker." Pop. Mech. 47:580, Apr., 1927.

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How to Dodge Electric Shocks. Pop. Mech. 47:290, Feb., 1927.

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Getting Gladiolus Flowers on Time. Gar. and Home Build. 45:165, Apr., 1927.
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Baking Science and Human Welfare. Amer. Food Jo. 22:t75, Mar., 1927.
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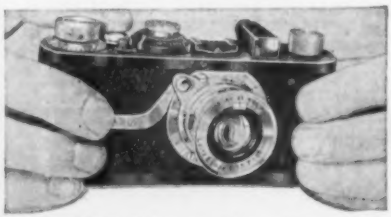

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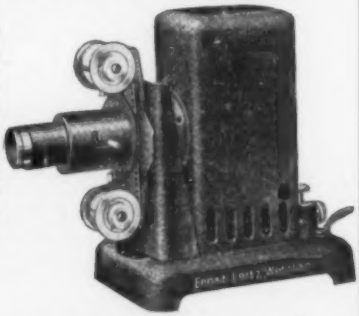

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Buying and Care of Furs. Jo. Home Econ. 19:198, Apr., 1927.

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GARDEN

The Garden and Home of Contentment. Gar. and Home Build. 45:145, Apr.

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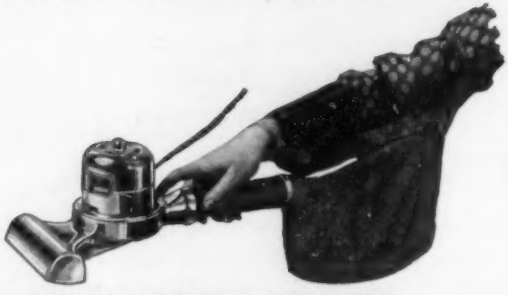

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Journal of Home Economics. 617 Mills Bldg., 700 17th Street N. W., Washington, D. C. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., New York. Weekly. 10c a copy $4.00 a year. Has a department, "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

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The Nation's Health. 22 East Ontario Street, Chicago, Ill. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpful to the science and hygiene teacher.

Photo-Era Magazine. Wolfeboro, New Hampshire. Monthly. 25c a copy, $2.50 a year. This magazine is for the beginner, the advanced amateur, and the professional photographer. It has much for the science department of universities, schools and summer camps, and will help instructors and pupils to make better photographs.

The Playground. 315 Fowler Avenue, New York City. Monthly. $2 a year, 25c a copy. Illustrated, devoted to outdoor recreation, for home, school and community.

Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles, well illustrated. Appeals strongly to elementary pupils. Suggests many construction problems.

Popular Science Monthly. 225 West 39th Street, New York City. Monthly. $2.50 a year, 25c a copy. A review in text and pictures of the news of science and invention, presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

Safety Engineering. 119 Nassau St., New York. Monthly. $3.00 a year, 25c a copy. A journal devoted to conservation of life and property, and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Science Classroom. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secodary science teachers.

Scientific American. Woolworth Building, New York. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated. Particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place New York City. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and, in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles, as a rule, are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

Science News-Letter. Science Service, 1115 Connecticut Ave., Washington, D. C. Weekly. 10c a copy $5.00 a year. Gives a valuable current summary of the progress of science, in a form usable in science classes.

Transactions of the Illuminating Engineering Society. 29 West 39th Street, New York. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.